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An assessment of the Marine Tactical Command and Control System (MTACCS)

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NAVAL POSTGRADUATE SCHOOL
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THESIS

AN ASSESSMENT OF THE
MARINE TACTICAL COMMAND AND CONTROL
SYSTEM (MTACCS)

by

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and
Michael J. Foley, Captain, USMC.

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This thesis is an assessment of the current efforts in the development of a Marine Corps Tactical Command and Control System (MTACCS). The Marine Corps has been developing MTACCS for more than twenty years. The recent cancellation of a key component subsystem and the DOD reorganization efforts of the late 1980's caused a two year period of dormancy in this program. The driving goal of this assessment is to develop an understanding of the strengths and the possible risks inherent in the "revitalized" program that is now in renewed development. The assessment effort examines the history of the program, the feasibility of the new concept, cost-effectiveness, systems engineering, and interoperability. Conclusions stress the importance of doctrinal consensus, adequate requirements definition, engineering the system as a whole, and evolutionary acquisition in the development of modern command and control systems.

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An Assessment of the Marine Tactical Command and Control System (MTACCS)

by

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ABSTRACT

This thesis is an assessment of the current efforts in the development of a Marine Corps Tactical Command and Control System (MTACCS). The Marine Corps has been developing MTACCS for more than twenty years. The recent cancellation of a key component subsystem and the DOD reorganization efforts of the late 1980's caused a two year period of dormancy in this program. The driving goal of this assessment is to develop an understanding of the strengths and possible risks inherent in the new "revitalized" program that is now in renewed development. The assessment effort examines the history of the program, the feasibility of the new concept, cost effectiveness, systems engineering, and interoperability. Conclusions stress the importance of doctrinal consensus, adequate requirements definition, engineering the system as a whole, and evolutionary acquisition of modern command and control systems.

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I. INTRODUCTION

A. PURPOSE OF THE THESIS

This thesis is an assessment of the current efforts in the development of a Marine Corps Tactical Command and Control System (MTACCS). The United States Marine Corps has been developing MTACCS for more than twenty years. Several significant events in the mid 1980's resulted in a major upheaval within the Department of Defense and a subsequent reevaluation of the MTACCS concept. The Goldwater-Nichols Defense Reorganization Act of 1986 and the termination of a key MTACCS subsystem in 1987 stand out as the most vital of these events. While development on other MTACCS subsystems continued, only nominal integration of these systems was achieved between 1988 and 1990. The concept has only recently been "revitalized" after two years of dormancy. [Ref. 1] The assessment of this newest version of MTACCS will be concerned with five important areas:

1. The impact of the termination of a key MTACCS subsystem for command and control of fire and air support.
2. The feasibility of the new MTACCS concept.
3. The cost-effectiveness of MTACCS.
4. Marine Corps combat development practices.
5. MTACCS level of interoperability.

The driving goal of this assessment is to develop an understanding of the strengths and possible risks inherent in the new MTACCS concept. Additionally, recommendations are proposed that offer methods of mitigating the impact of identified risk factors.

B. OUTLINE OF THE CHAPTERS

1. Chapter II. The Termination of MIFASS

The Marine Integrated Fire and Air Support System (MIFASS) was a recent Marine Corps attempt at developing a key MTACCS component subsystem for fire support. The MIFASS program was canceled in 1987 after almost twenty years in development. One result of the termination of MIFASS is the use of new approaches to the development and acquisition of Command and Control systems. MTACCS is based on these new ideas. Chapter II details the difficulties encountered during the MIFASS program that ultimately led to the termination of the project.

2. Chapter III. MTACCS Today: The Response to MIFASS

The "revitalized" concept is a response to many factors. Important among these factors is the termination of the MIFASS program. Chapter III describes the MTACCS concept as it is currently envisioned. MTACCS, however, is only now being defined. Many of the guiding directives and strategy documents are still in draft. While the basic thrust of the new concept is stable, some changes in concept definition are occurring even as this thesis is being written.

3. Chapter IV. Feasibility Assessment

The implementation of MTACCS is an extreme challenge. At least several of the objectives of MTACCS fall into the "high risk" category and may be difficult to achieve at any reasonable cost and expenditure of effort. The first assessment, then, is an evaluation of the feasibility of the MTACCS goals. While much of this evaluation is necessarily subjective, the question of feasibility must be addressed regardless of the lack of quantitative evidence.

4. Chapter V. A Cost-Effectiveness Assessment

It is often tacitly accepted that automation of a particular task has inherent benefits that always result in improved combat effectiveness. Is this the case with MTACCS? To what degree will automation of the command and control tasks bring about an improvement in combat effectiveness? The combat effectiveness assessment in Chapter V will address these questions. In addition, the cost of MTACCS must be related to its ability to increase effectiveness. Some investigation must be made to determine if spending funds on MTACCS is an optimal use of resources.

5. Chapter VI. Combat Development Assessment

Combat Development is a process used to determine the course of the Marine Corps in the years ahead. Combat Development affects doctrine, training, force structure, and equipment. The MTACCS system is a result of Combat Development practices. Chapter VI provides an overview of Combat Development and assesses its likely impact on MTACCS.

6. Chapter VII. MTACCS Interoperability Assessment

The fifth critical area concerns interoperability. In October of 1988, the Naval Research Advisory Committee (NRAC) released a report on the intra/interoperability of Marine Corps command and control systems. The report cited several interoperability concerns with MTACCS at that time and proposed several recommendations to improve the interoperability posture of the Marine Corps. An obvious question then is "have the recommendations been given consideration"? Chapter VII will provide an assessment of the interoperability efforts of MTACCS and the levels of interoperability expected to be achieved.

C. BACKGROUND AND HISTORY OF MTACCS

1. Background

a. The Need for an Automated Command and Control System

The National Security Act of 1947 requires that the Marine Corps provide rapidly deployable amphibious forces for contingency missions in support of the national strategy. A key statutory mission of the Marine Corps is to provide Marine Air Ground Task Forces (MAGTF) of combined arms, together with supporting air components, for service with the fleet in the seizure or defense of advanced naval bases and for the conduct of such land operations as may be essential to the prosecution of a naval campaign. The coordination of such a large number of forces and equipment deployed over a wide geographic area demonstrates the requirement for an automated command and control system to effectively manage the assets available. [Ref. 2:p 3-1]

In order to accomplish assigned missions, Marines are deployed in various states of readiness around the globe. In some cases, Marines and their equipment are prepositioned in strategic locations, in the vicinity of trouble areas. When Marines must be deployed, they must go through various phases and locations in order to ship their resources to the area of conflict. This requires an extensive amount of logistical and administrative processing, and validates the requirement for automation. [Ref. 2:p 3-1]

Marines train on a daily basis for the conduct of war. This training and the keeping of personnel records requires a large amount of time and effort spent, not on training, but on processing. An automated system of personnel and training record keeping could significantly raise the amount of time spent on training and increase record accuracy. [Ref. 2:p 3-2]

An automated command and control system that would be used in peace as well as combat would facilitate the prosecution of battle and make more effective use of the available resources. [Ref. 2:p 3-2]

b. The Purpose of MTACCS

The MTACCS concept is the implementation of separate, automation assisted Marine Air Ground Task Force (MAGTF) command and control systems which support tactical operations. MTACCS is to enhance the commander's decision making capability and provide the tools necessary for effective and efficient command and control. MTACCS is to support maneuver warfare, focus on the operational level of war, support MAGTF internal functional requirements, and focus on the MAGTF area of influence. [Ref. 1:pp 1,4]

c. Concept and Characteristics

The objective of the MTACCS concept is to provide MAGTF commanders with an integrated set of systems which can receive, process, display, store, and distribute essential information. Figure 1 portrays the MTACCS concept as it is currently envisioned. The subsystems shown will be defined and explained in detail in

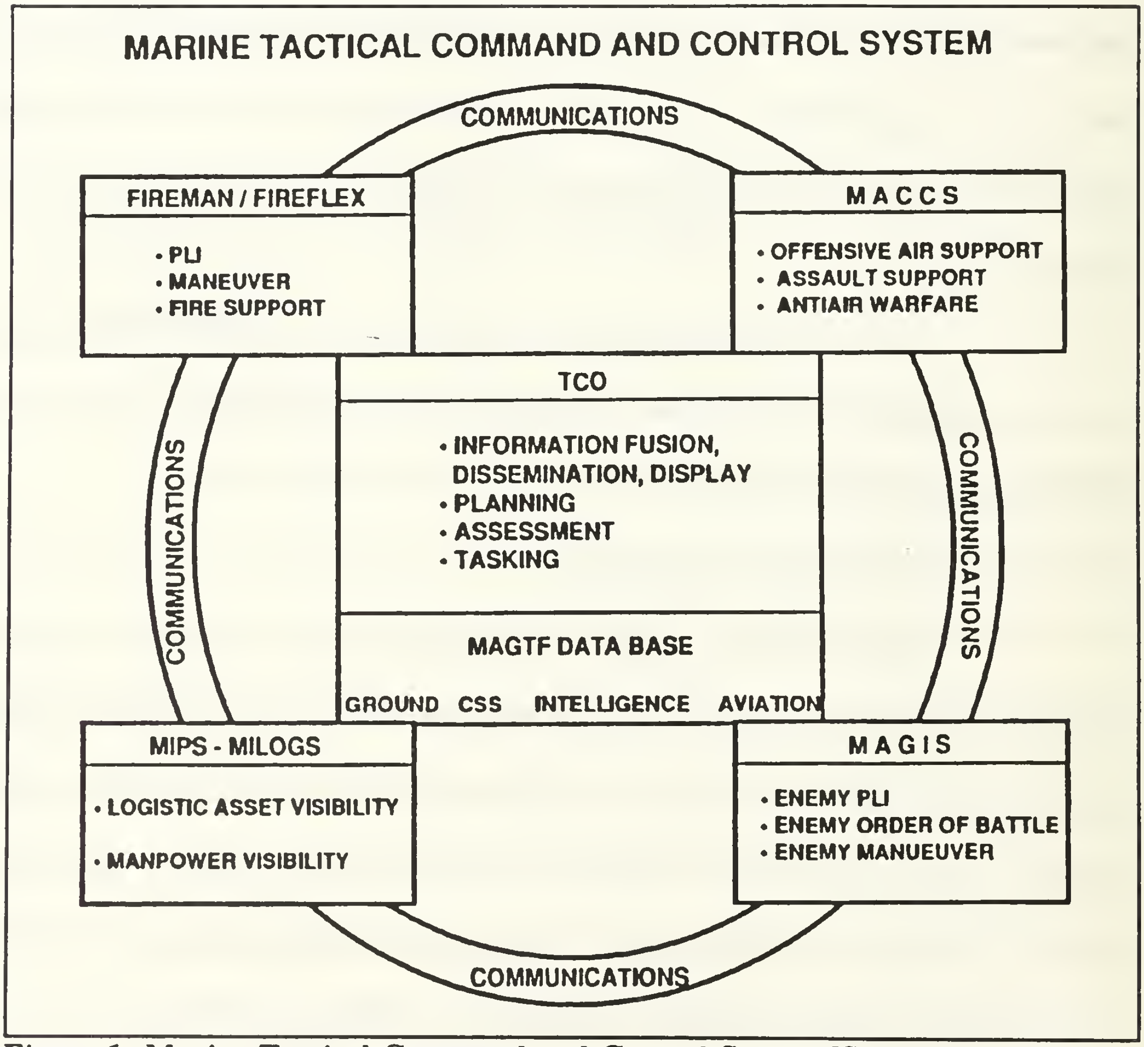

Figure 1: Marine Tactical Command and Control System [Source: MCCDC]

Chapter III. MTACCS is an engineering effort to manage the integration of developed and developing automated systems to support tactical operations. MTACCS will provide commanders with a semi-automated, secure, versatile, rugged, and integrated system of tools to assist them in effective command and control. It consists of functionally oriented systems using a common design philosophy, equipment, operational procedures, data bases, and where appropriate, integration with other systems external and internal to the Marine Corps. MTACCS is based upon reliable digital communications to enhance planning, direction, coordination, and control of Marine forces. MTACCS will eventually provide the commander with one system to support both tactical and non-tactical functions while providing fused and correlated information. [Ref. 1:p 6]

2. History

The MTACCS Master Plan of 1979 was the source for much of the history contained in this section. Figure 2 shows the evolution of the MTACCS component systems from 1969 to the present.[1]

The MTACCS concept first started in 1964, when the Commandant of the Marine Corps (CMC) tasked the Coordinator, Marine Corps Landing Force Development Activities [2] to act as the contracting technical representative for the conduct of Marine

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[1] In the figure, boxes with heavy borders denote systems that have been fielded. A detailed description of these systems is contained in Chapter III.

[2] The Marine Corps Landing Force Development Activities was redesignated Marine Corps Development and Education Command (MCDEC). MCDEC was later reorganized into the Marine Corps Research, Development, and Acquisition Command (MCRDAC) and the Marine Corps Combat Development Command (MCCDC).

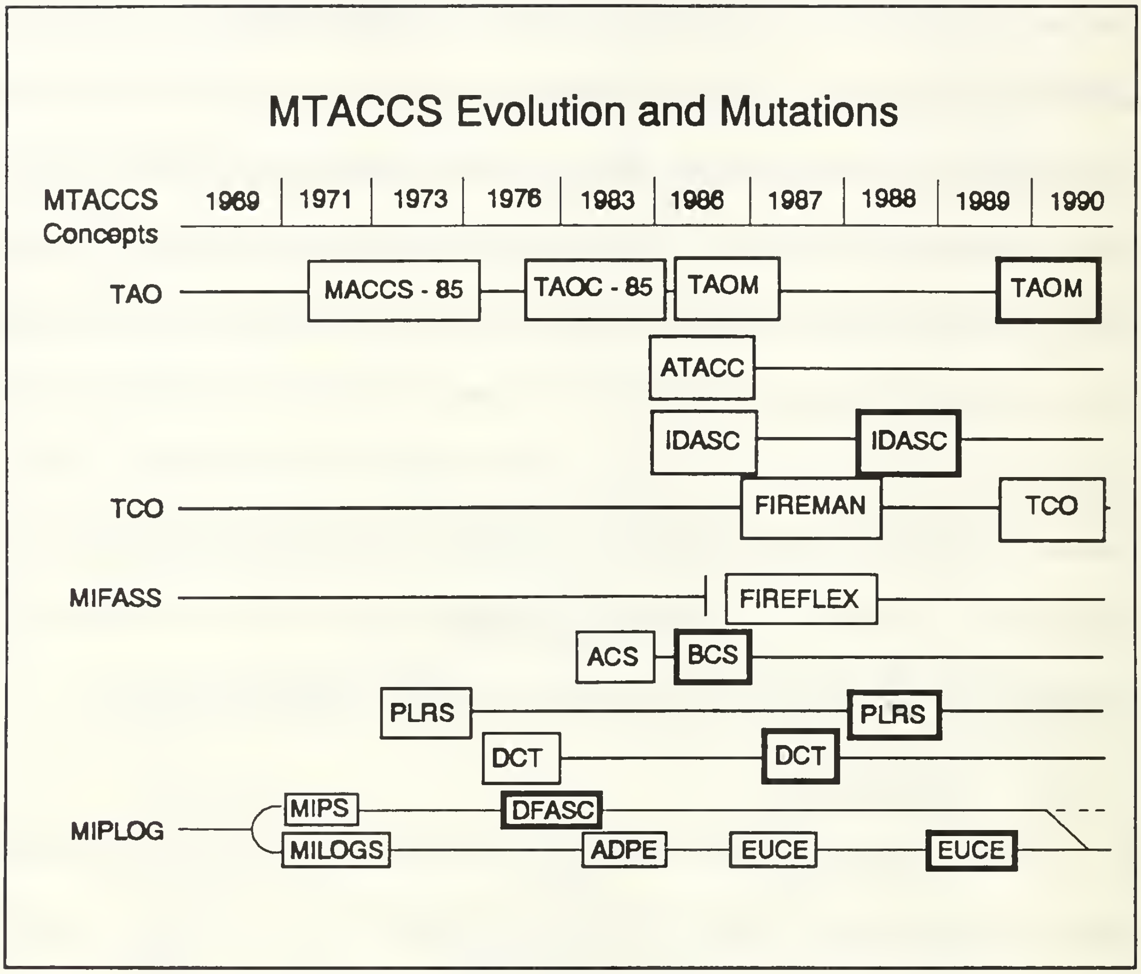

Figure 2: MTACCS Evolution and Mutations [Source: MCCDC]

tactical command and control studies by Informatics, Inc. and the Stanford Research Institute. A further task was to recommend provisions to ensure compatibility with other service and international service systems to be operational when MTACCS was fielded. The Informatics, Inc. study developed a technical system concept and an implementation concept. The technical system concept had five functional areas that included:

1. Tactical Combat Operations (TCO)
2. Tactical Air Operations (TAO)

3. Marine Integrated Fire and Air Support System (MIFASS)

4. Marine Integrated Personnel and Logistics (MIPLOG)

5. Communications (Comm)

Informatics proposed the establishment of a test bed consisting primarily of off the shelf items and currently available test equipment. The Stanford Research Institute defined and quantified the tactical command and control requirements.

On 16 February, 1969, the Naval Electronic Systems Command (NAVELEX)[3] was designated the Principle Development Activity (PDA). In June of 1969, the billet of MTACCS project coordinator was established in the office of the Director, Management Analysis Group. The mission of this MTACCS coordinator was to monitor and coordinate the entire MTACCS project through its development and system integration. In August of 1969, the Marine Corps Development Center was tasked to provide prototype definition, systems effectiveness analysis, and subsequent operational system development.

By August 1972, the test bed at Camp Pendleton, California had been completed and full scale evaluation of MIFASS had started. MIPLOG had evolved into two systems, the Marine Integrated Personnel System (MIPS) and the Marine Integrated Logistics System (MILOGS). In 1973, the TAO was redesignated Marine Air Command and Control System - 85 (MACCS-85). The Position Location Reporting System (PLRS), Tactical Warfare Analysis and Evaluation System (TWAES) and Tactical Exercise

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[3] NAVELEX later became Space and Naval Warfare Systems Command (SPAWAR).

Simulator and Evaluator (TESE) were added to the concept, bringing the total number of systems to ten.

In October of 1973, responsibility for the coordination of MTACCS was transferred to the development branch of the Research, Development, and Studies Division at HQMC. Less than two years later, a HQMC command and control systems coordinating committee was established with membership from each principle HQMC office concerned with the development and support of MTACCS and from MCDEC.

The first MTACCS Master Plan was published in 1976. The issuing directive required that the plan be updated annually. About this time, the requirement for a dedicated MTACCS communications system was deleted, and TWAES and TESE were combined into Tactical Warfare Simulation, Evaluation, and Analysis System (TWSEAS).

The Technical Interface Concepts were published in 1978 and provided basic inter/intraoperability criterion. [Ref. 3: pp 1-5 - 1-9]

In September 1979, the MIFASS contract was awarded to Norden Systems Incorporated for a projected cost of $44 million and a delivery date of October 1982. The following year, new Marine Corps standards were published in the Tactical Interface Design Plan (TIDP). This resulted in a requirement for a Unit Level Message Switch (ULMS), a significant increase in software documentation, and a $14 million increase in costs. After the Assistant Commandant of the Marine Corps (ACMC) was notified by SPAWAR that Norden would have a problem in meeting the delivery deadline, the ACMC decided to delete four requirements, defer eight others, and delay the delivery by twelve months. Major General D. B. Barker and a panel of senior officers conducted a

study of the acquisition of MIFASS. Their results described a number of problems with the acquisition process, with the Marine Corps' definition of requirements, and with a lack of consensus concerning doctrinal issues. Development continued with increasing costs and lengthening delays until MIFASS was finally terminated in May 1987 at a cost of $236 million.[4] [Ref. 4,5] MACCS-85 was renamed the Tactical Air Operations Module (TAOM) and is currently being fielded. The PLRS system was also fielded. Due to the cancellation of MIFASS, the cornerstone of the original MTACCS concept, the remaining systems (TCO, TWSEAS, etc.) continued development but only nominal integration of these systems was attempted. MTACCS was revitalized in 1989 and an Operational Concept document was published in April of 1990. [Ref. 1]

[4] This amount is based on a MIFASS chronology written by the last MIFASS ASPO. Several other figures have been published. In 1989, the GAO wrote "About $150 Million" was spent on MIFASS. [Ref. 5:p 23] The great disparity cannot be resolved.

II. THE TERMINATION OF MIFASS

A. INTRODUCTION

1. Purpose of this Chapter

The purpose of this chapter is to investigate the circumstances that led to the recent termination of a Marine Corps attempt to procure a command and control system. That system was called the Marine Integrated Fire and Air Support System (MIFASS). After nearly twenty years of development and an expenditure of more than $200 million, the program was terminated in 1987 while still in the full scale development phase.

The remainder of this introductory section describes the MIFASS system, provides a brief history of MIFASS, and introduces the key players involved in the procurement of MIFASS. Section B provides several viewpoints and opinions on the possible causes of the termination. Section C attempts to sort through all of the varied opinions and arrive at a determination of the most significant factors that contributed to the cancellation of the program.

2. A Description of the MIFASS System

The Marine Integrated Fire and Air Support System (MIFASS) was a subsystem of the Marine Tactical Command and Control System (MTACCS). It was designed to operate directly or indirectly with the systems included in the MTACCS concept and with other services and NATO systems as well. [Ref. 3] MIFASS was a combination of equipment, personnel, and associated procedures. They were to provide

a means for exercising command and control (C^2) of fire and air support assets within a Marine Air Ground Task Force (MAGTF). [Ref. 6:p D-3] MIFASS was to provide support in the immediate attack of targets of opportunity and to give automated assistance in fire planning, target intelligence, counter fire operations, nuclear and biological target analysis, forward area air defense, mission activity reporting, and low altitude airspace management.

MIFASS centers were to be located at various levels within the MAGTF acting as the primary agency for the control of all supporting arms. Suites of equipment were to be constructed around a set of software modules to enable a complete set of system capabilities. [Ref. 6:p I-5] MIFASS software was originally designed to provide automation to assist the MAGTF in operating within a new tactical doctrine implemented by a system of Fire and Air Support Centers (FASC). The basic tenet of fire support prior to MIFASS and the FASC concept had been decentralization (Figure 3). The FASC concept was to reorganize and centralize the C^2 of fire support (Figure 4). The FASC's were to assume the functions of both the Direct Air Support Center (DASC) and the Fire Support Coordination Center (FSCC), and selected roles of supporting artillery units and naval gunfire ships as well. [Ref. 6, 7:pII-2] The new FASC doctrine would employ MIFASS equipment to semi-automate both fire support coordination and air support coordination within one center. The established decentralized doctrine employed FSCCs to provide manual coordination of fire support and a DASC to provide manual coordination of air support. The change to a more centralized doctrine and the FASC concept was never officially endorsed or approved, but was supported by many key

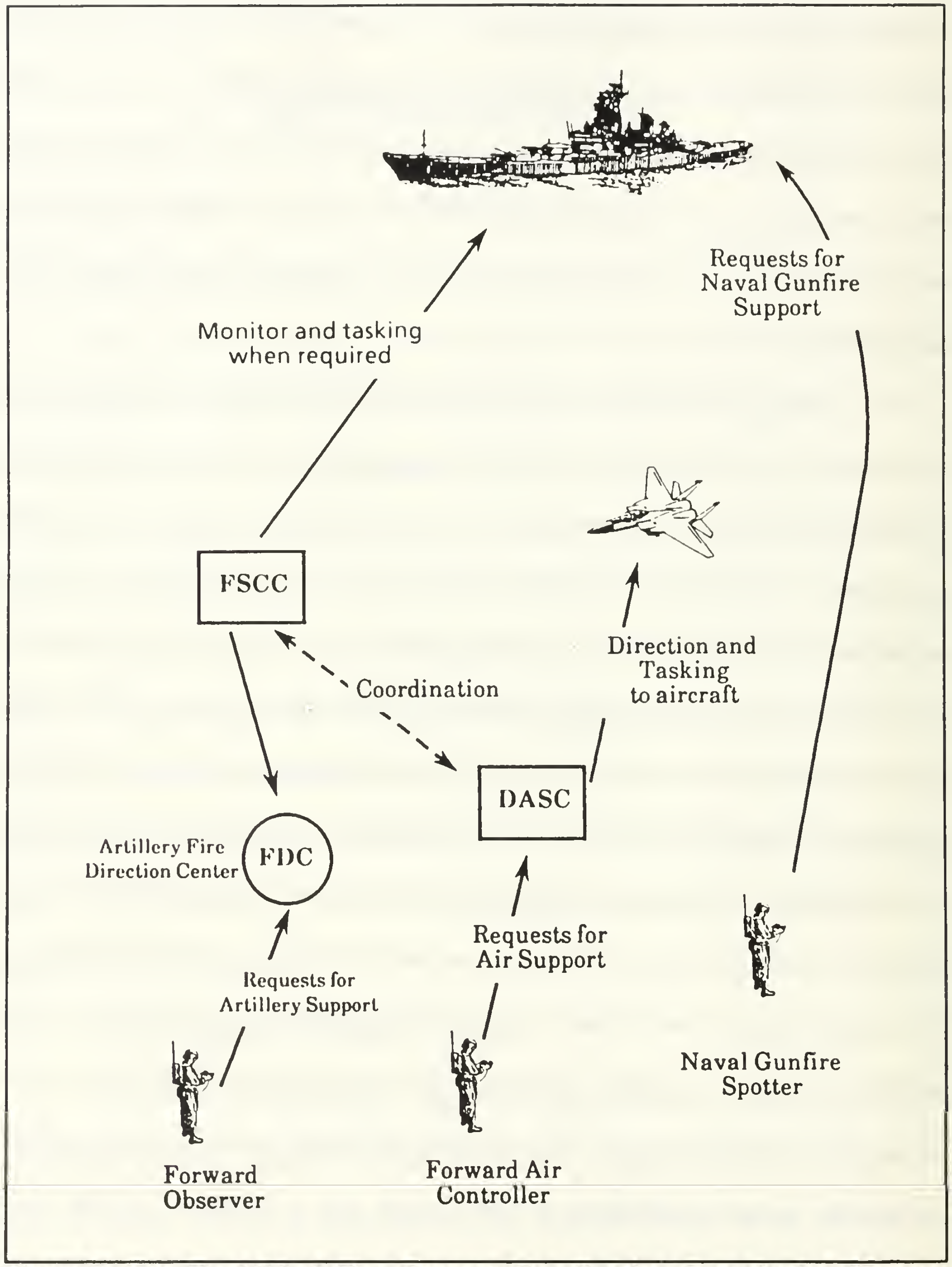

Figure 3: The Established Fire Support Coordination Organization [Source: Authors]

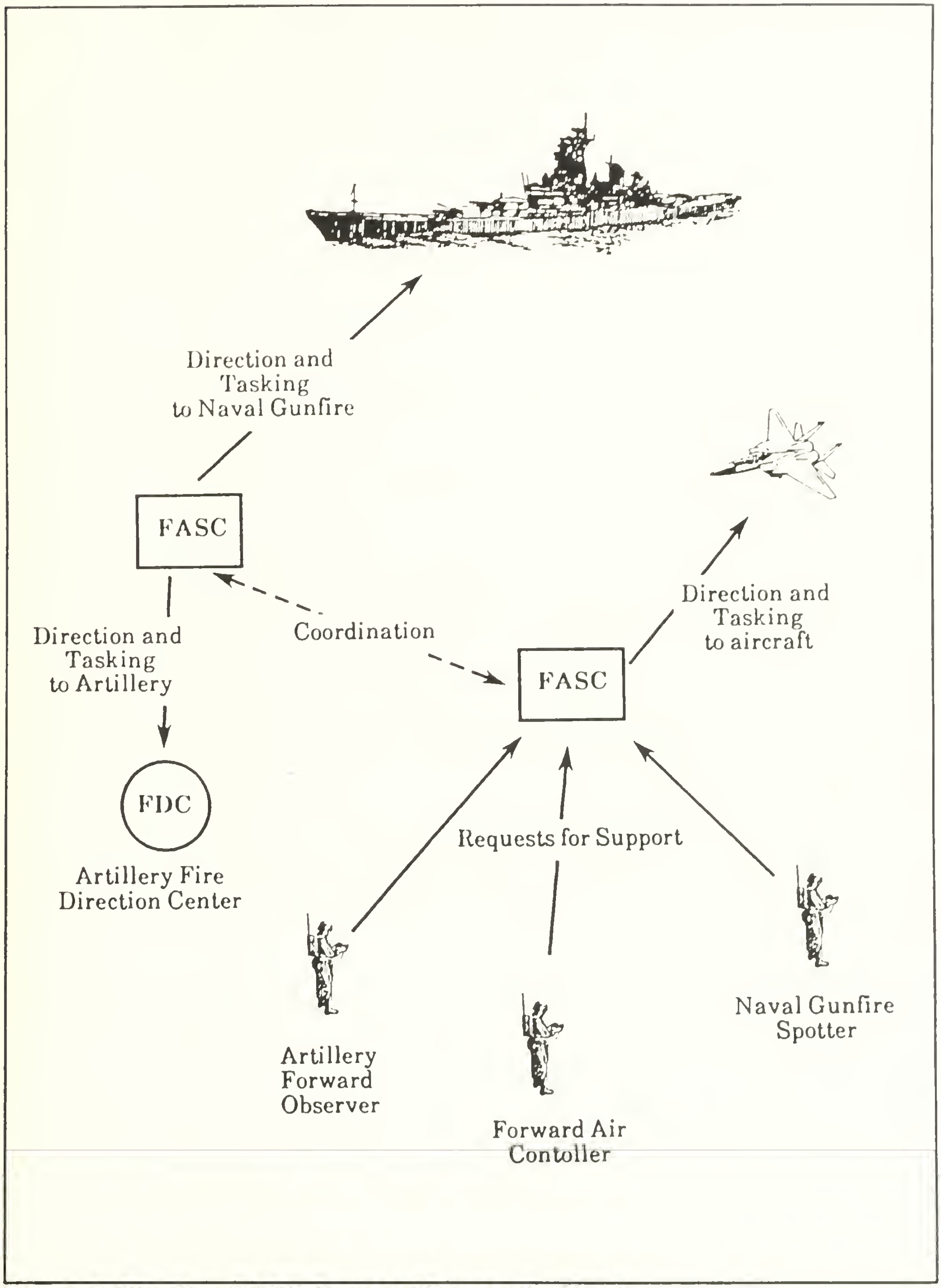

Figure 4: The New FASC Concept [Source: Authors]

decision makers in the Marine Corps. [Ref. 7:p D-3] This would later prove to be a key weakness of the MIFASS program. Although MIFASS was initially intended to support the more centralized fire support doctrine, the Marine Corps had great difficulty in its efforts to achieve a consensus acceptance of centralization. In the end, that consensus was never achieved. By 1983, the centralized doctrine and the FASC concept appear to have been abandoned. The problems that resulted from this lack of consensus are discussed in detail in Section B of this chapter.

MIFASS equipment consisted of real-time display and information processing equipment capable of displaying friendly unit and target locations and of processing requests for fire and air support. This equipment was to be located in the FASCs and artillery Fire Direction Centers (FDC's). Firing units would have small, hand held, off-line calculators to automate fire direction computations. Supporting arms observers would have been furnished Digital Communications Terminals (DCT) along with their manpacked radios in order to enhance communications with the FASC. The MIFASS concept envisioned supporting arms requests being routed simultaneously to the FASC in the area to be supported and the FASC who would control the unit providing the support. The senior FASC would clear the request by verifying friendly unit safety and conformance to other coordination, control, and limiting measures. Potential conflicts between ground and air support were to be coordinated laterally between FASCs.

MIFASS was a very far sighted concept. The development of this program was an extreme challenge to the Marine Corps. It would take nearly a quarter of a

century for the program to run its course. The next section provides a brief history of this ill-fated project.

3. MIFASS Chronology

The following is an abbreviated summary of more than twenty years of MIFASS history.

- 1964 - The Marine Corps hired the Stanford Research Institute and Informatics, Inc. to conduct Marine Tactical Command and Control studies. The results identified 5 functional areas to be developed, one of which was MIFASS.

- July 1967 - The first formal requirements documents describing MIFASS were published.

- February 1969 - Naval Electronic Systems Command (NAVELEX, later it became Space and Naval Warfare Systems Command (SPAWAR)) was designated the Principle Development Activity for MTACCS (including MIFASS) by the Chief of Naval Material at the request of the Commandant of the Marine Corps.

- June 1969 - The Marine Corps established a charter for MTACCS which delineated the functions of the Headquarters Marine Corps (HQMC) staff and established a MTACCS Project Coordinator.

- August 1969 - MCDEC was designated as the field agency test bed activity for MTACCS and was tasked to provide prototype definition, systems effectiveness analysis, and subsequent operational development.

- 1972 - An MTACCS test bed was established at Marine Corps Tactical Systems Support Activity (MCTSSA), Camp Pendleton, Ca. The MIFASS concept was the first to be tested and was found to be a valid requirement for continued development.

- December 1974 - In response to the test bed results, a MIFASS Required Operational Capabilities (ROC) was staffed, starting the formal acquisition/development of the system. The ROC was approved and published in 1975.

- March 1976 - A review of MIFASS design alternatives was held and it was decided to develop MIFASS with both the current organization and doctrine and with the

new organization (combine the DASC and FSCC into a FASC). This was not to be construed as approval of any organizational or doctrinal changes.

- February 1977 - Approval was granted for full scale development of a MIFASS Engineering Development Model (EDM). The question of which organization and doctrine to use remained unresolved and development was directed to proceed with both.

- September 1979 - A cost plus incentive fee contract was awarded to Norden Systems Incorporated (United Technologies Corporation). Cost projections were $44 million and a delivery date of October 1982.

- July 1980 - Assistant Commandant of the Marine Corps (ACMC) Committee met and established a requirement for a Unit Level Message Switch (ULMS) and increased software documentation of MIFASS as a result of the new Marine Corps wide standards promulgated in the Tactical Interface Design Plan (TIDP). Projected costs increased to $58 million and the delivery date slid to April 1983. At this time, Norden was directed to change all subcontracts to fixed price contracts.

- December 1982 - ACMC Committee was notified by the PDA that Norden would have problems in meeting the April 1983 delivery deadline due to problems in implementing the TIDP. The committee decided to delete four requirements and defer eight others. A developmental delay of 12 months was authorized. Major General D. B. Barker, DC/S for Training, chaired a study group formed at this time to review MIFASS requirements. Projected costs were $158.14 million with EDM delivery in April 1984.

- May 1982 - Chief of Staff's Committee reviewed the Barker study and decided to continue development of the EDM using both doctrines and organizations.

- July - December 1982 - The projected costs increased $14 million due to interface software for the Digital Communications Terminal (DCT), development of digital error correction, and to evaluate the feasibility of integrating the Tactical Combat Operations (TCO) System (another element of MTACCS).

- June 1983 - The ACMC Committee convened to review two ADMs:
  1. Approval for a modification allowing a six month extension for the EDM delivery date.
  2. The requirement for ACMC approval prior to expenditure of more funds on MIFASS.

  The decision was also made to conduct Operational Testing II (OT-II) using only decentralized doctrine and organization. Work around for software changes was estimated at $3 Million.

- July 1984 - ACMC Committee granted an extension of five months for Engineering Development Model (EDM) delivery and approved a 50/50 cost sharing plan, proposed by Norden, of the $13 million for continued development. SPAWAR, the Principle Development Activity (PDA), was directed to negotiate a cap on the MIFASS development costs with the contractor. Projected costs are $135 million with a delivery date of March 1985.

- May 1985 - The ACMC Committee met to modify MIFASS acquisition strategy. It was decided that a modified software package be completed with full capability included either in the MIFASS production model or in the Preplanned Product Improvement Model (P^3I). It was decided that the delivery date of the system be extended thirteen months and an additional $7 million be expended. Projected costs were $210.88 million with a delivery date of April 1986.

- October 1985 - During a status brief to the ACMC Committee, SPAWAR was directed to:
  1. Develop an acquisition plan based on competition for the production contract.
  2. Develop a finite list of required modifications.
  3. Complete a detailed R&D plan for MIFASS by task and year.
  4. Provide pros and cons of MIFASS as perceived by past and present First Marine Amphibious Force Test Directors.

- March 1986 - The ACMC Committee received a proposed improved acquisition plan from the PDA, and the finite list of required modifications which totaled $19.8 million.

- May 1987 - the ACMC recommended to the CMC the termination of MIFASS. Total funds spent on MIFASS exceeded $236 million. [Ref. 4]

4. Key Players and Their Responsibilities

No single individual was ever designated as the program manager for MIFASS. Program management was primarily accomplished through an Acquisition Coordinating Group. The Acquisition Coordinating Group was principally a decentralized assembly of personnel from HQMC staff sections and from the Marine Corps Development Center.

[Ref. 8] The acquisition organization used for the development of MIFASS is shown in Figure 5.

a. The Acquisition Coordinating Group (ACG)

This coordinating group consisted of action officer representatives from the Marine Corps Development Center, the HQMC Research, Development and Studies staff section, the Installations and Logistics staff section, and the Command, Control, Communications, and Computer Systems (C^4 Systems) staff section. The functions of the group included:

1. Write and execute the Acquisition Strategy Plan (ASP) and the Material Acquisition Process (MAP).
2. Exchange information and coordinate actions of its members.
3. Document program history.
4. Recommend program management actions to the Acquisition Program Sponsor (APS) who was the Director, Command, Control, Communications, and Computer Systems. [Ref. 8:p 16]

(1) Acquisition Sponsor Project Officer (ASPO). The leading member of the group was the Acquisition Sponsor Project Officer (ASPO) who was responsible for MIFASS systems acquisition. The ASPO was a representative from the program sponsor, the C^4 Systems branch at HQMC. His primary duties included:

1. Coordinating staff action for the program sponsor.
2. Ensuring the accuracy of the ROC and the Life Cycle Cost Forecast (LCCF).

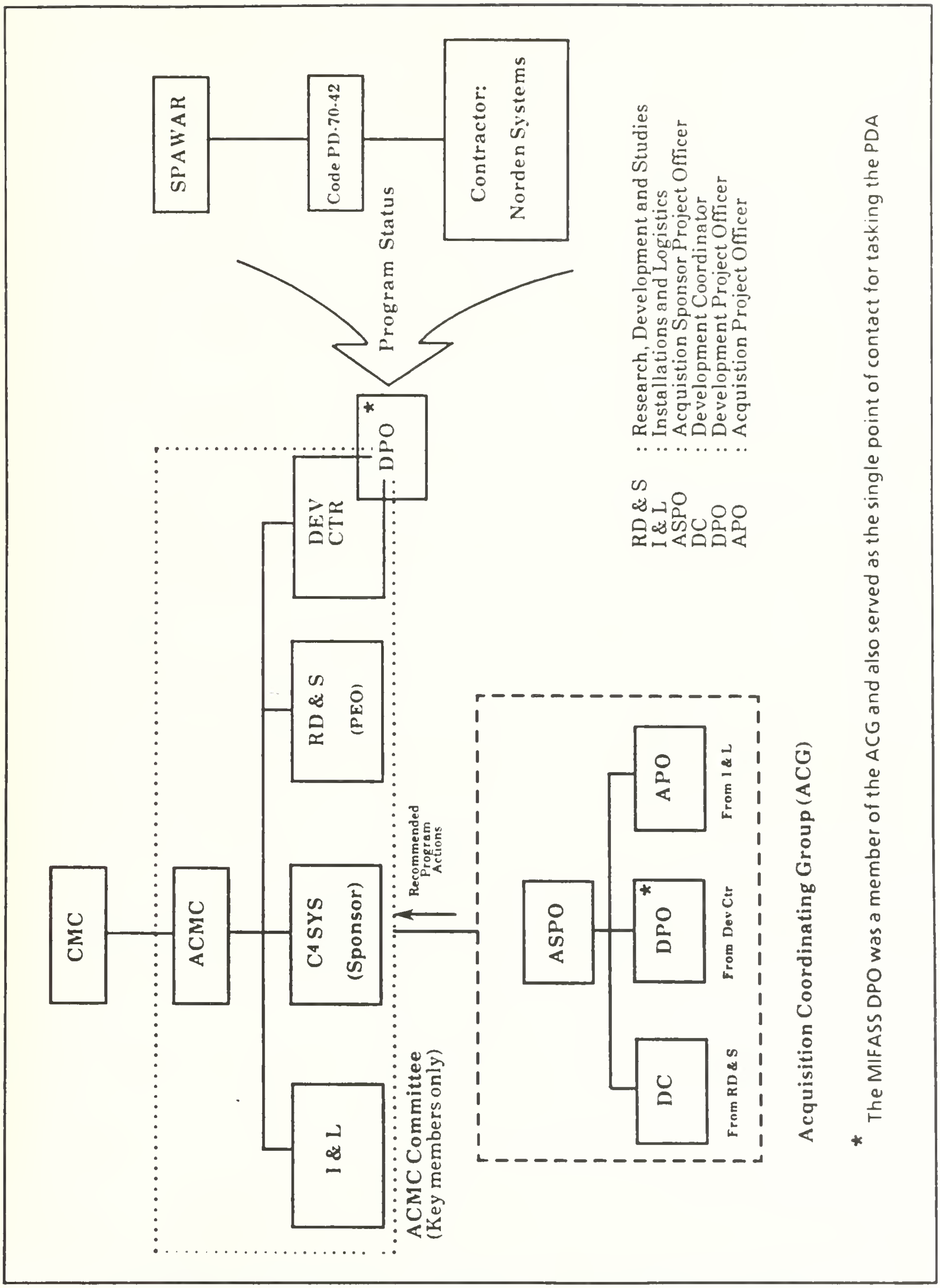

Figure 5: MIFASS Acquisition Organization Diagram [Source: Authors]

3. Developing the ASP, MAP, and the Manpower Training Plan (MTP).

4. Preparing the program objective memorandum (POM).

5. Providing program action recommendations to the sponsor for approval. [Ref. 8:p 17]

(2) Development Project Officer (DPO). The second key member was the Development Project Officer (DPO) who was responsible for the day to day management of the MIFASS development program. The DPO was a representative from the Development Center. His principle responsibilities were:

1. To act as the single Marine Corps point of contact for tasking the Principle Development Activity (PDA).

2. To prepare RDT&E work directives.

3. To prepare Statements of Work.

4. To provide program review briefings. [Ref. 8:p 17]

(3) Acquisition Project Officer (APO). The Acquisition Project Officer (APO) was the third key member. The APO was a representative from the Installations and Logistics staff section at HQMC. His responsibility was for the management of the logistical, technical, and engineering aspects of production, fielding, operations, support, and retirement. His major responsibilities included:

1. Developing the Integrated Logistics Support Plan (ILSP).

2. Assisting in the development of LCCF data to support program initiation and documentation.

3. Ensuring reliability, maintainability, supportability, and other logistical requirements are included in the system design.

4. Assisting the ASPO in the programming of funds. [Ref. 8:p 16]

(4) Development Coordinator (DC). The Development Coordinator (DC) was the final key member of the Acquisition Coordinating Group. The DC was a representative from the Research, Development, and Studies staff section at HQMC. His responsibility was to coordinate the MIFASS acquisition program. His major duties were:

1. To maintain the master project file.

2. To assist in the preparation of the ASP and the MAP, and the programming of funds. [Ref. 8:p 16]

b. HQMC Staff

The Commandant of the Marine Corps (CMC) was authorized to make the final Acquisition Category IIc (ACAT IIc) decision of continuing or canceling MIFASS. The Assistant Commandant of the Marine Corps (ACMC) was designated the Acquisition Executive (AE). As AE he was required to monitor and control the acquisition development of MIFASS and report to the CMC. The AE had decision authority for funding and schedule changes for MIFASS acquisition. The ACMC chaired an ad hoc group of selected General officers called the ACMC Committee. The purpose of this committee was to act as a program review body, but not as a milestone review. As problems with MIFASS surfaced at an increasing rate, the Committee assumed many

of the responsibilities previously held by the Acquisition Program Sponsor (Director, Command, Control, Communications, and Computer Systems Division). [Ref. 8:p 16]

c. *Deputy Chief of Staff for Research, Development, and Studies*

> The office of the Deputy Chief of Staff for Research, Development, and Studies was responsible for acquisition matters for ground combat systems from program initiation until the systems were ready for production. [Ref. 9:p 54]

The Deputy Chief of Staff for Research, Development, and Studies (DC/S RD&S) acted as the Program Executive Officer (PEO)[5] for MIFASS development up to Milestone III. His primary responsibilities included:

1. Providing the Development Coordinator (DC) to the Acquisition Coordinating Group.
2. Coordinating the review and approval of all MIFASS requirement documents.
3. Ensuring a link between Mission Needs, Research Development, Test and Evaluation (RDT&E).
4. Preparing Acquisition Decision Memorandums. [Ref. 8:p 18]

d. *Director, Command, Control, Communications, and Computer Systems*

The Acquisition Program Sponsor (APS) was the Director, Command, Control, Communications, and Computer Systems Division (DirC^{4}SysDiv). His responsibilities included:

1. Providing the MIFASS Acquisition Sponsor Project Officer (ASPO) to the Acquisition Coordinating Group.

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[5] The Program Executive Officer (PEO) is generally described as a middle manager responsible for several separate programs.

2. Interoperability, intraoperability, and compatibility interface of MIFASS with other Systems.

3. Reviewing all program initiations and requirements for MIFASS.

4. Being the principle point of contact for management and planning guidance.

5. Assessing the capability, suitability and cost of the program.

6. Initiating the mission area analysis for MIFASS in determining operational requirements. [Ref. 8:p 19]

e. The Deputy Chief of Staff for Installations and Logistics

The office of the Deputy Chief of Staff for Installations and Logistics became the acquisition focal point during the production and development stages and throughout the remainder of the systems' life cycle. [Ref. 9:p 54]

The Deputy Chief of Staff for Installations and Logistics (DC/S I&L) would have assumed the duties as the PEO had MIFASS reached the production and deployment phase. His major responsibilities included:

1. Providing the Acquisition Project Officer (APO) who is a member of the Acquisition Coordinating Group.

2. Planning and coordinating ILSPs up to Milestone III.

3. Ensuring reliability, availability, maintainability, and quality assurance were given due consideration during MIFASS development. [Ref. 8:p 18]

f. The Marine Corps Development Center

The Director of the Marine Corps Development Center (DirDevCtr) was subordinate to the Commanding General of the Marine Corps Development and Education Command (MCDEC). Although the Development Center was not directly subordinate to

the DC/S RD&S, there was an obvious need for close coordination between the two. The RD&S staff section was responsible for development policy within the Marine Corps. The Development Center implemented that policy. The major responsibilities of the director included:

1. Providing the MIFASS Development Project Officer (DPO) to the ACG.
2. Managing the Marine Corps Long Range Studies Program that generated a need for MIFASS, and submitting requirement documents to DC/S RD&S for HQMC staffing.
3. Conducting Mission Area Analysis as requested.
4. Acting as the single agency responsible for the management of work performed by the PDA and associated contractors. [Ref. 8:p 20]

g. *The Principle Development Activity (PDA)*

SPAWAR was the PDA for MIFASS and it's mission was to support the Marine Corps by providing for the design, development, integration, test and evaluation, and procurement of MIFASS to satisfy operational requirements. SPAWAR managers received guidance and direction from CMC, but still reported to the Commander of SPAWAR.

B. SEVERAL VIEWPOINTS ON THE TERMINATION OF MIFASS

1. What Went Wrong?

Many opinions on this subject have been published in the three years since the announcement of the termination and many people have addressed the question: "What

went wrong?". Not surprisingly, these numerous perspectives have offered varied, and sometimes conflicting, answers to that question. The termination of the MIFASS program can undoubtably be traced to many interrelated factors. In this section, the viewpoints and opinions of several key people, agencies, and groups will be examined.

2. The Barker Working Group Study of MIFASS, 1982

By late 1981, several MIFASS program perturbations had led to significant cost increases and schedule delays. Many key decision makers within the Marine Corps were developing serious doubts that the MIFASS program was still viable. The Assistant Commandant of the Marine Corps (ACMC) directed that a working group be established to revalidate the MIFASS requirement, determine cost effectiveness, and develop recommendations concerning the continuation of the MIFASS program. [Ref. 10:pp 2-4] This group was chaired by Major General D. B. Barker, USMC, and is referred to throughout this thesis as the Barker Working Group.

By April of 1982, the working group had completed its evaluation. The report was very critical of the excessive size and weight of MIFASS. It stated:

> Easily the most significant problem associated with MIFASS is its impact on the mobility and survivability of maneuver command posts at every level. Although the Marine Tactical Command and Control System (MTACCS) Master Plan states that equipment size and weight must not exceed the transportation capability available to the using unit...there is little evidence of adherence to that guidance. [Ref. 11:p 22]

Significant among the group's conclusions was its declaration that "the 1979 MIFASS Required Operational Capability (ROC) was invalid" [Ref. 11:p 38]. The group

found it necessary to submit its own ROC as a recommended replacement for the 1979 ROC. Other key observations included:

1. Despite years of test bed development, the government was not fully prepared to go to contract in 1979 because it had not clearly specified the functional flow diagrams which were to form the basis for software development.

2. The contractor underestimated the complexity and difficulty of MIFASS software development.

3. The Marine Corps organization for development is inadequate. [Ref. 11:p 27]

Several courses of action were studied by this group. Among these were to continue the MIFASS program in accordance with the 1979 ROC, to significantly modify the program, or to terminate MIFASS and look elsewhere for a command and control system. Continuation of the program without modification was flatly rejected. Major modifications to the program were recommended including the merger of MIFASS with the Tactical Combat Operations (TCO) program and deletion of the FASC concept. [Ref. 11:p 41] The ACMC committee chose not to implement the study's recommendations because they required major changes, and the belief at the time was that MIFASS was only six months away from operational testing [Ref. 8:p 37].

3. The General Accounting Office, 1983-1986

During the period of 1983 to 1986, both the Congress and the GAO took a specific interest in the development of battlefield command and control (C2) systems. At least five GAO reports reviewed Army and Marine Corps fire support C2 systems during these years. Generally, there was heightened interest by the Services, OSD, GAO,

and the Congress in clarifying the need to have both battlefield support systems, the Army's Advanced Field Artillery Tactical Data System (AFATDS) and MIFASS. [Ref. 12:p 10] Marine Corps justification for MIFASS was AFATDS' inability to integrate combined air/ground operations and its lack of a real time coordination capability with aircraft.

In October of 1983, the General Accounting Office (GAO) reviewed both the Army's and the Marine Corps' efforts to automate their fire support command and control functions. The GAO report to the Secretary of Defense stated:

> The potential for common fire support command and control systems in the Army and the Marine Corps has not been exploited in spite of the Department of Defense's (DOD's) policies promoting standardized systems and equipment. Although the missions are similar and the fire support systems need to communicate with each other, each service is developing its own systems. This has led to possible duplication of development efforts and interoperability problems. [Ref. 13:p 1]

This appears to be the first alarm being sounded that standardization is being ignored and that "possible duplication" exists. The GAO position was critical:

> Mission differences exist, and while these differences may constrain the degree of commonality, they do not preclude it...[Ref. 13:p 4] Neither service has explained why these differences require systems with totally unique hardware and software. [Ref. 13:p 6]

The GAO opinion here has substantial merit. There are extensive similarities in the fire support procedures used by the Army and the Marine Corps. Marine Corps artillerymen are trained at the Army Artillery School at Fort Sill, Oklahoma. Marines use

several Army field manuals for artillery operations[6]. Much of the equipment and weaponry used is identical. While there are important, critical differences[7], the significant degree of commonality in fire support procedures should not be overlooked.

While this report states its case clearly and raises good questions, little attention appears to have been paid to it. If considerable duplication was taking place, it would seem to be only common sense that, sooner or later, one of the programs would become indefensible and the ax would fall. Secretary of Defense Mr. Caspar Weinberger, however, did relatively little during his tenure to constrain the requests of the services. [Ref. 14:p 123] Given the ever increasing defense budgets of the early 80's, the duplication was fiscally possible. If the Army and the Marine Corps wanted to go their separate ways, the barest of justifications was sufficient to gain DOD approval. It is doubtful this duplication was intentional. Redundancy is often the chosen method of ensuring survivability. In this case, however, redundancy may simply have been tolerated.

4. The Institute for Defense Analyses (IDA), early 1987

In July of 1986, the Under Secretary of Defense for Research and Engineering requested that IDA perform an independent assessment of the fire support command and

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[6] FM 6-20 "Combined Arms Operations", FM 6-30 "The Field Artillery Observer", FM 6-40 "Field Artillery Cannon Gunnery", and FM 6-50 "The Field Artillery Battery" are just a few examples.

[7] The Marine Corps has organic fixed wing fire support, for example, and plans for extensive employment of Naval gunfire.

control systems being developed by the Army and the Marine Corps. In his letter, he emphasized "Considerable momentum is developing to combine the two programs." [Ref. 15:p 1] In directing the IDA study, the Secretary of Defense, Mr. Weinberger, stated that DOD would "ensure maximum cross-service commonality and interoperability of these systems." [Ref. 16:p 1] Aside from any problems that either program may have been having, both Congress and the GAO had, by this time, long been questioning why the Army and the Marine Corps were both developing separate systems to do principally the same tasks.

By early 1987, the IDA report had been completed. The intent of the study was to provide an independent assessment of the potential to consolidate the MIFASS and AFATDS programs [Ref. 12:p 7] The study examined the feasibility of three options:

1. Both services field MIFASS.
2. Both services field AFATDS.
3. Army fields AFATDS and the Marine Corps fields MIFASS.

The study first evaluated the ability of AFATDS to meet the needs of the Marine Corps without modification. The general finding was that, without modification, AFATDS would not meet the requirements of the Marine Corps as then stated. It further concluded that "Although it appears that AFATDS could be adapted to Marine Corps needs, this adaptability needs to be demonstrated" [Ref. 12:p 66]. While it was understood that AFATDS would require modification, the IDA study still painted a poor picture of MIFASS in three important areas: cost, weight, and interoperability. It stated:

> MIFASS for the Army would weigh between two and five times as much as AFATDS...The variation in weight due to the uncertainty as to whether the Army would populate its centers with one string of equipment or two strings as the Marine Corps has planned. [Ref. 12:p 44]

Five years after the Barker Working Group, MIFASS was once again declared to be too heavy. Also of major note is their finding that fielding a sufficiently ruggedized version of AFATDS to the Marine Corps would cost

$285 Million to $355 Million less than fielding MIFASS, a savings of 65-80%. [Ref. 12:p 48] Worse yet, fielding MIFASS to the Army "could quadruple the cost of the Army program." [Ref. 12:p 64] From an interoperability standpoint, MIFASS would have little commonality with any of the other MTACCS Systems [Ref. 12:p E-20] At the present time, AFATDS is optimistically expected to reach full scale development in 1992. [Ref. 5:p 13]

The IDA report concluded that the Marine Corps should conduct an Adaptability Evaluation Program (AEP) to validate the concept of adapting AFATDS to the needs of the Marine Corps. This AEP could also help to validate potential cost and weight reductions. [Ref. 12:p 78]

> Assuming the results of the AEP are positive, the Marine Corps, in coordination with the Army, should supplement and modify the AFATDS software (in ADA) to implement the Marine Corps unique interfaces. The Marine Corps should select the Non-Developmental Item (NDI) equipment that most clearly fits its needs. [Ref. 12:p 82]

5. The Marine Corps Viewpoint, mid 1987

a. Why Should MIFASS be Terminated?

At the time that MIFASS was terminated, there were several groups and individuals within the Marine Corps that had direct input into the ultimate fate of the program. Many were convinced by now that MIFASS would not work and had been searching for reasons why it should be terminated rather than asking if it should be terminated. MIFASS still had support, however, and a strong consensus for or against was certainly lacking. While opinion on the fate of MIFASS was divided, each of the Marine agencies and commands had similar opinions on the performance of MIFASS during testing. The one theme that each appeared to express was simple: MIFASS did have the potential to enhance Fire Support C^2 at higher levels of command, but it was of little value, and indeed inhibiting, at lower levels. Unfortunately, very little documentation exists containing the thoughts of the decision makers. Reliance must instead be placed upon several memoranda containing, primarily, the conclusions of the agencies briefing the Commandant at the final MIFASS review held on 11 May 1987.

b. The Final MIFASS Review, 11 May 1987

This section describes the presentations and opinions that were delivered by key participants at the final review of the MIFASS program.

(1) The users perspective: Colonel W. A. Hesser. A key participant at the final review was Colonel W. A. Hesser, Commanding Officer, 7th Marines, whose

regiment was used in the operational testing. His conclusions, as summarized in a Memorandum for the Record were:

1. MIFASS did not perform as well as the current manual system.
2. MIFASS communications are inadequate.
3. Reliability is unacceptable.
4. Throughput and PLI (PLRS Location Information) is inadequate.
5. Restricts mobility (Especially infantry battalion).
6. Hard to learn and troubleshoot.
7. Commander will not be tied to console because the console is not adequate for tactical decision making. [Ref. 17: Appendix B, Tab 2]

Note the first deficiency. He does not state that MIFASS does not work, but only that it doesn't work as well as the current manual fire support procedures. When asked by the Deputy Chief of Staff for Manpower to estimate the percentage of failure for MIFASS specific items, Colonel Hesser responded with 20%. While this would be high for an operational system, it is not so for an incomplete system that is still in the Full Scale Development phase. There was obvious concern that MIFASS would not provide a significant advantage over current methods. In a separate issue paper, Colonel Hesser conjectures on a reason for the MIFASS deficiencies:

> We decided to implement a new doctrine (the Fire and Air Support Center) along with the new system but changed our mind three years later. Simply, the Corps was never sure exactly what it wanted. [Ref. 18]

From Colonel Hesser's viewpoint, MIFASS basically worked. He implied, however, that it was not what the Marine Corps needed for fire support coordination because of the doctrinal and organizational changes required to make it effective. Also, the existing communications equipment did not fully support the needs of the MIFASS architecture. In a nutshell, the Marine Corps got what it asked for, but not what it needed. This was, in part, because the Marine Corps changed course and turned back to the centralized doctrine with the FSCCs and the DASC instead of embracing the new FASC concept and a more centralized approach.

(2) The I MAF Test Directorate. Directly above Colonel Hesser during the operational testing was the I MAF[8] Test Directorate. Their conclusion was that "Regiment and above FSCC's and the DASC can be made to work satisfactorily." [Ref. 17:Appendix B] In order to make this feasible, they felt four things were required. Of these four, only two were MIFASS specific: a new computer, and software cleanup/modification. Their only other negative comment was that the equipment at the infantry battalion and fire direction center level was too heavy. Also, in their opinion, "MIFASS worked somewhat better than generally perceived by most observers" (separation of MIFASS specific problems from the problems of other systems is necessary). [Ref. 17: Appendix B, Tab 1]

[8] I MAF is the First Marine Amphibious Force. MAF's were redesignated Marine Expeditionary Forces (MEF's) in 1987.

(3) Marine Corps Operational Test and Evaluation Activity (MCOTEA). The analysis of the Marine Corps Operational Test and Evaluation Activity (MCOTEA) is more critical of MIFASS. They state that:

> MIFASS does not enhance the control, coordination, and integration of fire support. In many respects, MIFASS inhibits the integration of supporting arms with the scheme of maneuver of the supported force. [Ref. 17:Appendix B, Tab 3]

On the subject of operational suitability, they report that "MIFASS has a significant adverse impact on infantry mobility," and "MIFASS cannot be employed effectively in the current organization and does not meet the needs of the commander." [Ref. 17: Appendix B, Tab 3] It must be pointed out that the "current organization" being referred to is the decentralized doctrine using separate Fire Support Coordination Centers and Direct Air Support Centers. MIFASS was not intended to support this decentralized approach and had to be significantly reworked to make the attempt.

(4) Required Operational Capability Working Group. Another group represented at the final review was the Required Operational Capability Working Group. While they were originally organized to determine just what the Marine Corps needed MIFASS to do, this is not apparent from their recommendations. The summary from the final review bears repeating here:

> The current system is not broke, organization and procedures are fundamentally sound and provide an adequate framework for an integrated air & fire support system. [Ref. 17: Appendix B, Tab 4]

The ROC working group went on to say that while some assistance is needed in fire support, it is "primarily, doctrine and training." They recommended "limited organizational change -- additional capability for the regimental FSCC."

[Ref. 17: Appendix B, Tab 4] This clearly contradicts the FASC concept (combined semi-automated fire and air support coordination) that lies at the core of MIFASS. The group that was supposed to determine the requirements for MIFASS instead found that MIFASS was not necessary.

(5) The Final Decision. Based on the information and opinions presented to him at the final review, the Commandant, General P. X. Kelley, decided on the following course of action:

1. Terminate MIFASS.
2. No immediate commitment to any Tactical Data System acquisition.
3. Expand requirements review.
4. New system definition study (evolutionary development).
5. Pursue enhancements to equipment procurement.
6. Deliberate participation in AFATDS. [Ref. 17: Appendix C]

(6) The Embarrassment of MIFASS. Terminating the MIFASS program was embarrassing. Without a doubt, everyone concerned with MIFASS felt a sense of failure. As with any failure, questions were asked and fingers were pointed back and forth laying blame. There were significant problems with the operation of the MIFASS system during the testing. Even though many of the problems were not the fault of the contractor or MIFASS specific hardware/software, blaming the failure on the MIFASS system itself could make the cancellation decision more palatable. After the termination

of the program, it was certainly much more common to hear the phrase "MIFASS failed" than it was to hear "The Marine Corps failed".

6. Space and Naval Warfare Systems Command (SPAWAR), 1987

The last briefing at the final MIFASS review came from Space and Naval Warfare Systems Command. Highlights from their brief to the Commandant include:

1. The full MIFASS configuration was too complex a first step.
2. The communications architecture used for the MIFASS EDM was high risk.
3. The slowness of operation masks MIFASS functional utility. [Ref. 17]

On the subject of operational requirements, they "agree with the working group that decentralization/simplification was necessary. A single system solution is not necessary or desired." [Ref. 17]

Within weeks of the cancellation of the MIFASS program, Space and Naval Warfare Systems Command (SPAWAR) published an overview of the program and lessons learned during the development. One of the key points made by this report was that:

> The MIFASS EDM generally met the requirements for which it was designed. The hardware units functioned as specified and were suitable for the tactical environment for which they were intended. The software generally functioned as intended. [Ref. 19:p 6-1]

The liberal use of the word "generally" reflected SPAWAR acknowledgement of some technical difficulties, but none apparently that were considered to be major failures of the system.

The SPAWAR report is interesting because it does not specifically address the question: "What were the significant problems and failures of the MIFASS program?" If the system generally performed as it was designed, then what was wrong with it and why was it canceled? This appears to be another implied opinion that they got what they ordered, but not what they needed or wanted. The report gives a history of MIFASS and it implies that MIFASS development was poorly managed and, as a result, was excessively delayed and costly. Delays and cost increases, however, were an attribute of virtually every program at that time. MIFASS was not canceled because it was behind schedule and over budget. Although these are legitimate problems, the SPAWAR report fails to define the real factors that led to the termination of the MIFASS program.

Another interesting aspect of this report is that it accepts no responsibility for any of the mismanagement it attributes to the program. Everything is either the fault of the Marine Corps or the contractor, Norden Systems. While it can certainly be argued that these two made mistakes, it is difficult to believe that the Principle Development Activity (PDA) is totally without fault, yet SPAWAR considered themselves blameless.

There is an implication in the SPAWAR report that there were too many requirements changes and too many waivers approved. Indeed, there were many changes and the waivers did number at least 200. Were all these changes the problem, or were they attempts at correcting other problems such as poor initial requirements definition? Unfortunately, this question can not be answered within the scope of this thesis. It is not unreasonable, however, to conjecture that the waivers were a necessary effort required to

salvage a program in trouble, rather than a result of the simple inability of the contractor to perform.

7. Current Perceptions, 1987 to the Present

a. The Donald Geving Thesis

In September of 1987, Captain Donald Geving, USMC, devoted his Masters Thesis at the Naval Postgraduate School to address the failure of MIFASS. Some of his background research has been quoted earlier in this thesis. His conclusions declared that three major areas doomed the MIFASS program:

1. Poor requirements definition.
2. A flawed matrix organization.
3. Interoperability problems. [Ref. 8:p 50]

While his first and third conclusions appear to have merit, the emphasis that he places on the "flawed matrix organization" may be excessive. Was the organization itself a key contributor to the failure? Probably not. The next section will offer arguments that address why the organization was merely a hindrance to the program.

b. Deputy Program Manager for MAGTF C^2 Systems

Colonel Michael Stankosky, USMC, is the current Deputy PM for MAGTF C^2 systems at the Marine Corps Research, Development, and Acquisition Command (MCRDAC) and was a member of the Research, Development, and Studies staff at the time of the final review of MIFASS. Colonel Stankosky has been quoted as

saying that we have failed miserably in the past because we have treated the development of command and control systems like building a tank, for example, where designers try to complete complex systems at once. Rather than develop a complex command and control system in one ambitious step, we should commit to a gradual development, with evolutionary improvements that can build upon smaller successes. [Ref. 20:p 27] This opinion is interesting because it presents the idea that the problem itself is too big. A new systems engineering and acquisition methodology must be charted to solve the problem a little at a time. His position here, then, is that MIFASS failed because the Marine Corps tackled the problem all at once. There is some truth in this idea, to a point, but developing systems a piece at a time may invite interoperability problems if a well defined architecture is not established.

C. IDENTIFYING THE PROBLEMS WITHIN THE MIFASS PROGRAM

1. Why the Program was Terminated

In May of 1987, the Commandant was faced with a MIFASS system that had real deficiencies. While some of his key advisors still had hope, others felt that the system was beyond help and no longer viable. Opinion was divided. Had no other reasonable alternative existed, the program probably would have continued with major modifications. An attractive alternative, however, did exist.

By simply allowing the Army and the Marine Corps to both develop systems to do essentially the same tasks, the Defense Department was taking some risk. Though not a deliberate action, it was laying the foundation for the termination of one of these

programs. If one or the other were to experience major problems, or if the budget were to decline, this duplication of effort would become indefensible. When both of these conditions occurred, the loser was MIFASS. It is doubtful that this duplication was intentionally fostered in order to ensure at least one of the programs would be successful. It is more plausible that the Secretary of Defense was convinced of a legitimate need to pursue different courses of action due to the divergent missions and procedures of the two services involved.

The IDA study broke the back of the MIFASS program. The Army's AFATDS was shown to be superior in virtually every category of any importance. With the IDA study in hand, both the House and Senate Authorization Committees proposed to zero MIFASS funding in their versions of the fiscal 1988 Defense Authorization Bill. [Ref. 21:p 110] Given the mounting Congressional and OSD pressure to cancel the program, there was only one rational conclusion that the Commandant could reach: recommend the termination of MIFASS and fall in with the AFATDS program. Under the circumstances of that day, MIFASS was properly and justifiably killed. The next question, then, is "Why did AFATDS look like a better program ?" Simply put, it was better because the Army made a few good key decisions and the Marine Corps made a few mistakes. The most significant of the Army's good decisions was to develop the software for their AFATDS program first and the hardware last. The key advantage to this strategy is the availability of the newest technology when the time comes to decide on hardware. The process of developing software for MIFASS took several years. By settling on hardware first, the Marine Corps was guaranteed to have equipment that was

outdated before it was even fielded. This is obvious now, given a 20/20 hindsight, but the rapid pace of technological advances was not so obvious then. The most sensible approach, if there is an idea of the final architecture, is to proceed with software development as early as possible. [Ref. 22:p 8]

2. The Problems Within the MIFASS Program

a. Common Weaknesses in Defense Programs

Several opinions on the MIFASS failure have been presented. Many of these viewpoints are one-sided perspectives that fail to see the "big picture". This section will sort through these opinions and draw some conclusions concerning which were the most significant of the problems.

It has been established in study after study that there are weaknesses common to nearly every Defense program. J. Ronald Fox, a former Assistant Secretary of the Army responsible for procurement, lists the following trends as most significant:

1. Setting requirements for the most sophisticated systems attainable, often irrespective of cost.
2. Underestimated schedules and costs of major programs.
3. Changes in program and contract requirements.
4. Lack of incentives for contractors and government personnel to reduce program costs.
5. Shortage of trained, quality personnel. [Ref. 14:p 32]

The MIFASS program is a textbook illustration of all of these common weaknesses, as well as several others. The following paragraphs provide evidence to defend this claim.

b. MIFASS Tried to do too Much

While MIFASS may not have been the "most sophisticated system attainable", there is some evidence that it was designed to do too much. Automation of some fire support tasks was a welcomed effort, but the designers of the system lost the support of the users when it was decided that MIFASS would accomplish many tasks that did not need automation. Many at the infantry battalion level were not amused that a heavy, resource guzzling system was being developed to automate tasks at their level that were being performed satisfactorily by the current manual method.

c. Underestimation of Schedules and Costs

As early as 1982, it was obvious to the Barker Working Group that the contractor had underestimated the complexity and difficulty of MIFASS software development. These poor estimations were directly responsible for the cost and schedule overruns. Norden Systems, however, does not bear the full burden for the lack of accuracy in their estimations. Norden was significantly handicapped by the lack of decisiveness within the Marine Corps concerning the application of the FASC concept. This wavering of requirements led to change after change. Norden apparently did not have the experience to predict this level of requirements changes.

d. Changes in Program and Contract Requirements

Poor initial requirements definition was without doubt the most serious of the program deficiencies. Without a clear direction to pursue, the program changed course time and time again. New doctrine and procedures had not yet been formally sanctioned, yet a system was already being developed to support the new concepts.

When the initial ROC was written, it concentrated far too heavily on technical requirements and failed to identify the needs of the Marine Corps in mission terms. This ROC was then replaced by another in 1979 which was also judged by the Barker Working Group to be without value. The simple lack of a valid, realistic requirements document was a devastating deficiency of the program.

According to Lieutenant Colonel Louis L. Boros[9], USMC:

> Nearly one third of the developmental costs of MIFASS can be attributed to the "better mousetrap syndrome"; that is, each time the Marine Corps transferred a project officer, his successor added to, or in some way changed, the original set of requirements. [Ref. 23:p 42]

e. Lack of Incentives to Reduce Program Costs

Little could be determined concerning the incentives for government personnel to reduce costs. Traditionally, few incentives exist, but no information was available to confirm that this was the case with MIFASS.

The contractor had little incentive, if any, to reduce costs. The initial MIFASS contract, accounting for a large portion of the funding, was a cost plus incentive

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[9] Lieutenant Colonel Boros served as the Aviation C^2 officer with the Proponency & Requirements branch of the MAGTF Warfighting Center.

fee contract. With the contractor guaranteed to recoup approved costs, they had no real need to attempt to keep costs down. This problem was recognized and all contracts after the initial one were written as fixed price.

f. Shortage of Trained, Quality Personnel

Colonel Hesser (CO of the regiment that tested MIFASS) drew particular attention to this factor in an issue paper that he presented to Major General R. "M" Franklin , USMC, DC/S, RD&S. His stinging comments declared that "during the past eight years of MIFASS development, not a single MIFASS acquisition project officer has been promoted... With a single, non-promotable officer at HQMC in charge of development, the Marine Corps simply was not dedicating sufficient assets to the problem". [Ref. 18] The lack of trained quality personnel was a key factor. The best Marines simply did not want to be acquisition project officers. There was widespread belief that an assignment in acquisition was a career setback that was difficult to recover from. In addressing this same issue in response to Colonel Hesser's comments, Brigadier General R. R. Porter wrote "The acquisition field is not a lucrative one for the majority of officers because of the perception that it does not lead to promotion" [Ref. 24] The allegation that none of the MIFASS ASPOs were promoted enhances that perception making it even more difficult to dispute.

g. Underestimation of the Complexity of the Task

It was recognized that the MIFASS program would push the limits of technology. It was a farsighted concept intended to anticipate the needs of the Marine

Corps in the 1980's. The Marine Corps relied on Stanford Research Institute, Informatics Inc., and Norden to provide realistic, competent estimates of the complexity of the task. It does not appear that the extensive software development necessary was fully understood or sufficiently stressed by these contractors.

h. Lack of Consensus Concerning Doctrine

When faced with complex problems that have few, if any, precedents, senior managers often rely on consensus building to determine the best course of action. In the case of MIFASS, achieving a consensus concerning doctrine proved to be rather difficult. One can only speculate on the cause of this difficulty. The complexity of the task was overwhelming. The centralization issue can sharply divide opinion.

i. The Marine Corps Organization for Acquisition

Most of the principles involved have asserted in some way or another that the matrix organization utilized to develop MIFASS was a poor system. While the matrix organization was clumsy and inefficient, to blame the failure of the program on the organization is short sighted. Certainly, the organization was weak, but the real problems of MIFASS were rooted in other issues. There was a stifling lack of consensus concerning doctrine. This lack of consensus may be partially attributable to the weakness of the acquisition organization. Captain Geving asserted in his thesis that the organization caused a "decision strangulation". This factor could have accounted for the great difficulty encountered in making the formal decision to accept the FASC concept and break cleanly with established decentralized procedures. Had the FASC concept been

fully agreed upon and had sound requirements been established at the very beginning, it is possible, but doubtful, that the weakness of the matrix organization alone would have resulted in major problems.

For the most part, criticism of the Marine Corps acquisition organization focused on three claims:

1. No one was "in charge".
2. Management by committee was inefficient and ineffective.
3. MIFASS suffered from "decision strangulation" because of the large number of people who could effectively veto decisions. [Ref. 25:p 134]

"Management by committee" did appear to be a drawback. The lack of clear command channels was a problem typical of the majority of the defense acquisition programs prior to the Defense Reorganization Act of the late 1980's. There is little evidence, however, to support the other claims.

The most valid criticism of this organization would be that it was slow to react to the problems within the MIFASS program. Virtually insurmountable problems should have been obvious from the beginning. Recognizing and coping with these problems was a slow and tedious process involving a lot of people. But Marines <u>did</u> recognize the problems. Marines <u>did</u> recommend solutions and decisions <u>were</u> <u>made</u> to implement or ignore those recommendations.

While day to day program management by committee may have been cumbersome there was certainly "someone in charge" from a big picture point of view.

Numerous Acquisition Decision Memoranda (ADM) were published outlining key strategy decisions. The correctness of those decisions, however, rested on the shoulders of the decision maker. Given the best advice in a timely manner, the decision maker can still make the wrong decision. The acquisition organization appears to have presented the decision makers with sufficient information to make the right decision. In many cases, choices were made that, given the benefit of hindsight, appear to have been wrong.

Political pressures, cognitive bias, personal agenda, and parochial attitudes all could have contributed to those decisions. The impact of these factors is certainly difficult to assess, but they provide a likely explanation for making the "wrong" decision when given all of the information necessary to choose correctly.

D. CONCLUSIONS AND LESSONS LEARNED

1. Conclusions

The Commandant of the Marine Corps made the correct decision in 1987. MIFASS was indefensible from a budgetary standpoint and it was not what the Marine Corps needed at the time.

There were four key problems within the MIFASS program:

1. A lack of consensus concerning the doctrinal issue of centralization versus decentralization.
2. Unstable requirements definition that failed to state requirements in mission terms.
3. Underestimation of the complexity of the task.
4. Adherence to the traditional approach of concentration on hardware first and then the software.

The clumsy and inefficient management system was a hindrance to the program, ***but the only devastating problem was the lack of the foundation necessary to establish the program in the first place: sound initial requirements definition based on appropriate doctrine.***

The unfounded initial definition, and the failure to agree on doctrinal justification that followed, led to interoperability problems, cost increases, and program delays. By 1987, the MIFASS program was the victim of the Serengeti Phenomenon[10]: the slowest thing on the plain in the morning is breakfast and anything that limps, dies. MIFASS limped, AFATDS did not.

2. Lessons Learned

The Marine Corps has learned many lessons from the failure of MIFASS. The old matrix organization has been replaced with a dramatically different acquisition system. In response to the Goldwater-Nichols Reorganization Act of 1986, and the termination of MIFASS in 1987, the procurement business in the Marine Corps has been radically changed. A thorough description of this new acquisition organization is presented in Chapter III of this thesis.

Hopefully, a lesson has been learned concerning requirements definition. The recently published Marine Corps Directive on Acquisition drives the point home:

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[10] The Serengeti Phenomenon was a term used by Radm Flanagan, USN, Superintendent's Guest Lecturer, NPS, October 1990, in reference to the ill-fated Navy P-7 Anti-submarine Warfare aircraft.

> The ROC should identify operational requirements not hardware solutions. It should provide a range of values vice a fixed point requirement. A poorly written ROC will overly constrain potential alternatives for meeting the operational requirements and will jeopardize the success of the acquisition program. [Ref. 26:p 9-5]

It is unlikely that new Marine Corps systems will try to tackle so much at one time in the future. Wary of falling into that trap again, current Marine Corps philosophy embraces the ideas of modular, evolutionary acquisition using non-developmental items as much as possible. The "build a little, test a little, field a little" approach will be used to prevent another MIFASS from happening. Overall, the Marine Corps responded to the MIFASS failure in a big way. A description of that response follows in Chapter III. Will the response be sufficient to prevent further disappointments? That is one of the driving questions behind this assessment effort.

III. MTACCS TODAY: THE RESPONSE TO MIFASS

A. INTRODUCTION

The United States Marine Corps is a proud organization. The failure of MIFASS was not taken lightly. The response to that failure would be far reaching, but MIFASS was not the only factor. There were many contributing factors that, when summed together, virtually demanded a reorganization of the acquisition system. The Goldwater-Nichols Reorganization Act of 1986[11], the embarrassment of MIFASS in May 1987, the appointment of a new Marine Corps Commandant, General Alfred M. Gray on 1 July 1987, and the completion of a critical report by the Naval Research Advisory Committee[12], were all key contributors. Together they forced sweeping organizational changes throughout the Marine Corps.

Several initiatives were undertaken to strengthen the Marine Corps in its combat effectiveness and in its management of defense resources. The scope of these initiatives was rather broad, but some of the more important objectives can be summarized as follows:

1. Revitalize the MTACCS concept to correct the deficiencies identified by both the MIFASS failure and the Naval Research Advisory Committee (NRAC).

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[11] The Goldwater-Nichols Reorganization Act forced major changes on Defense acquisition. It is discussed in greater detail in Section E of this chapter.

[12] The NRAC report on Intra/Interoperability deficiencies within MTACCS is addressed in more detail in Chapter VII.

2. Reorganize the acquisition organization within the Marine Corps to capitalize on the lessons learned from MIFASS and to comply with the Goldwater-Nichols Reorganization Act.

3. Implement several warfighting enhancement initiatives (such as the addition of a fourth rifle company to each infantry battalion).

The numerous warfighting enhancement initiatives will have a significant impact on the requirements of MTACCS. They are mainly organizational and equipment changes designed to provide the most efficient distribution of Marine Corps assets. Assessment of these initiatives, however, is beyond the scope of this thesis.

This chapter will focus on defining three key issues:

1. The current MTACCS concept.

2. A configuration management tool called the Field Development System (FDS).

3. The current MTACCS acquisition and development organization and methodology.

B. THE "REVITALIZED" MTACCS CONCEPT

1. The Need for Reevaluation

In the past, MTACCS was defined as a "conceptual association of C^2 systems to support tactical operations using where feasible, common equipment, operational procedures, databases, and design philosophy...." [Ref. 3:p 1-1] Exactly what that meant is unclear now and was probably unclear even to those who wrote it more than eleven years ago. To many people, "a conceptual association" meant that MTACCS subsystems were developed somewhat independently with little regard for interoperability and

configuration management. In fact, this appears to have been the majority belief. MTACCS was developed from the outset in just that way and serious deficiencies and setbacks ensued. By 1988, the program had ground virtually to a halt. MIFASS had been terminated, Congress had passed the Goldwater-Nichols Reorganization Act, and it appeared that the time had come to step back and reevaluate the entire MTACCS concept. As a result of this reevaluation, efforts have been undertaken to update the original MTACCS concept into the planned Marine Corps Command, Control, Communications, Computers, Intelligence, and Interoperability (C^4I^2) Architecture.[13] [Ref. 27:p 8]

2. The Vision of General Gray

A key objective of the new Commandant would be to develop a Marine Corps that is lighter "making both Marines on the ground and the gear in their hands more mobile and more lethal". [Ref. 28:p 15]

In General Gray's view, attrition, firepower, and frontal assault are no longer the key to combat success; superior technology, purposeful movement, the application of combat power at the proper time and place, initiative and the influence of commanders through their command, control, communications, and intelligence will allow Marines to engage any enemy and win. [Ref. 29:p 107]

These ideas will have a significant impact on the development of MTACCS component systems. Someone once said "For every vision, there is an equal but opposite

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[13] Quoting from Signal magazine, "In 1988, the Marine Corps merged the inextricably entwined, but often estranged, military disciplines - communications and intelligence. The Corps, acknowledging this as a "bold move", went even further by adding the seemingly intractable field of intelligence interoperability." [Ref. 29:p 107]

revision". While some may feel that user support for MTACCS will wane with General Gray's retirement in June of 1991, there is evidence that MTACCS will continue to maintain its course.

It is General Gray's belief that MTACCS decisions have been made based on the input of all of the senior leadership and he is confident that the focus of the Marine Corps will be maintained. [Ref. 28:p 16]

3. The Definition of MTACCS

a. The Difficulty of Definition

Clear self expression is a trait that is dying in America[14]. The numerous documents and publications that describe both MTACCS and the Field Development System (FDS) are heavily crowded with a multitude of obscure terminology. The excessive use of acronyms, vague cliches, and "buzzword" phrases, significantly hampers any attempt at developing a thorough understanding. In his book Command, Control, and the Common Defense, Lieutenant Colonel C. Kenneth Allard, USA, echoed this opinion when he wrote "The writings by experts in the field of command and control can be an impenetrable thicket of buzzwords, jargon, and obscure usages." [Ref. 30:p 148] This problem remains ubiquitous. It is not merely a trivial nuisance. The simple lack of a clear, understandable program definition can be devastating to a project. With this limitation in mind, the "revitalized" MTACCS concept is herein defined.

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[14] Paraphrased from Dr. Donald Abenheim, Naval Postgraduate School, 12 January 1991.

b. Key Elements of MAGTF C^2

The Commandant of the Marine Corps has identified several key elements that are required to support the Marine Air Ground Task Force (MAGTF). These elements include:

1. The tactical command, control, communications, and intelligence (C^3I) systems for Ground C^2, Aviation, C^2, and Combat Service Support C^2.

2. Approved C^2 architectures that synthesize the placement and use of tactical Command, Control, Communications, Computers, and Intelligence (C^4I) systems.

3. Supporting communications equipment.

4. Command, control, communications, and intelligence (C^3I) systems aboard amphibious ships.

5. Common hardware and software building blocks.

6. Interoperability requirements and standards programs.

7. A strong configuration management process that does not allow perturbations of the elements unless the impact on the whole is assessed. [Ref. 27:p 1]

MTACCS is the "umbrella concept" intended to provide these elements to the MAGTF commander. [Ref. 27:p 2]

c. The MTACCS Concept

The MTACCS program will be pursued as a series of integration phases. Each phase will merge the numerous developing and disparate components and subsystems into a consistent system that achieves a predetermined level of integration. [Ref. 31] Instead of building MTACCS in one ambitious step, the Marine Corps will gradually build the system by making evolutionary improvements in computer

software and hardware during each phase. [Ref. 20:p 27] These integration phases will be called Field Development System events. FDS 1 is the first of these events. The Field Development System is described in detail in Section D of this chapter.

The MTACCS Operational Concept Document was published on 3 April 1990. That document "defines MTACCS, outlines the operational concept, describes MTACCS component systems, and provides a concept for development/acquisition". [Ref. 1]

In the Operational Concept, MTACCS is defined as "the integration of separate automation assisted MAGTF Command and Control (C^2) Systems which support tactical operations." [Ref. 1] It is important to stress that MTACCS is a **concept only**. It is the integration of component systems to allow those systems interoperability in order to provide integrated and automated support for MAGTF C^2. [Ref. 32:p 3] "MTACCS will achieve interoperability among automated systems by utilizing a common family of data processing hardware, a common operating system and support software." [Ref. 33:p 1] MTACCS is an engineering effort to:

1. Select common hardware and software.
2. Select MTACCS architecture.
3. Test the architecture.
4. Manage the integration of the component systems. [Ref. 33:p 1]

Rather than simply allow for a vague "conceptual association," MTACCS is expected to "integrate" the separate systems. Now the role of MTACCS is better defined.

Separate C^2 systems will be developed for each of the four functional areas:

1. Ground C^2: Tactical Combat Operations (TCO), Multi-service Advanced Field Artillery Tactical Data System (MAFATDS).

2. Aviation C^2: Marine Air Command and Control System (MACCS).

3. Combat Service Support (CSS) C^2: Marine Integrated Personnel System (MIPS), Marine Integrated Logistics System (MILOGS).

4. Intelligence: Marine Air-Ground Intelligence System (MAGIS).

Figure 6 depicts the MTACCS concept. The Tactical Combat Operations (TCO) system will be the hub of MTACCS and is the system intended for MAGTF command and control. As such, TCO is intended to be the system that integrates the component systems of MTACCS.

d. The MTACCS Architecture

Pacific Northwest Laboratories (PNL) is the system engineer and integrator for MTACCS. PNL is responsible for architecture development and implementation, system requirements definition and standards development, systems engineering and development, and configuration management. [Ref. 34:p iii]

The proposed architecture has been defined in a draft hardware/software recommendation prepared by PNL. This architecture consists of four layers as shown in Figure 7.

> The hardware layer will be comprised of a family of computers whose varying capabilities will be matched against the varying needs of different echelon levels. MTACCS Common Application Support Software (MCASS) envelops the two

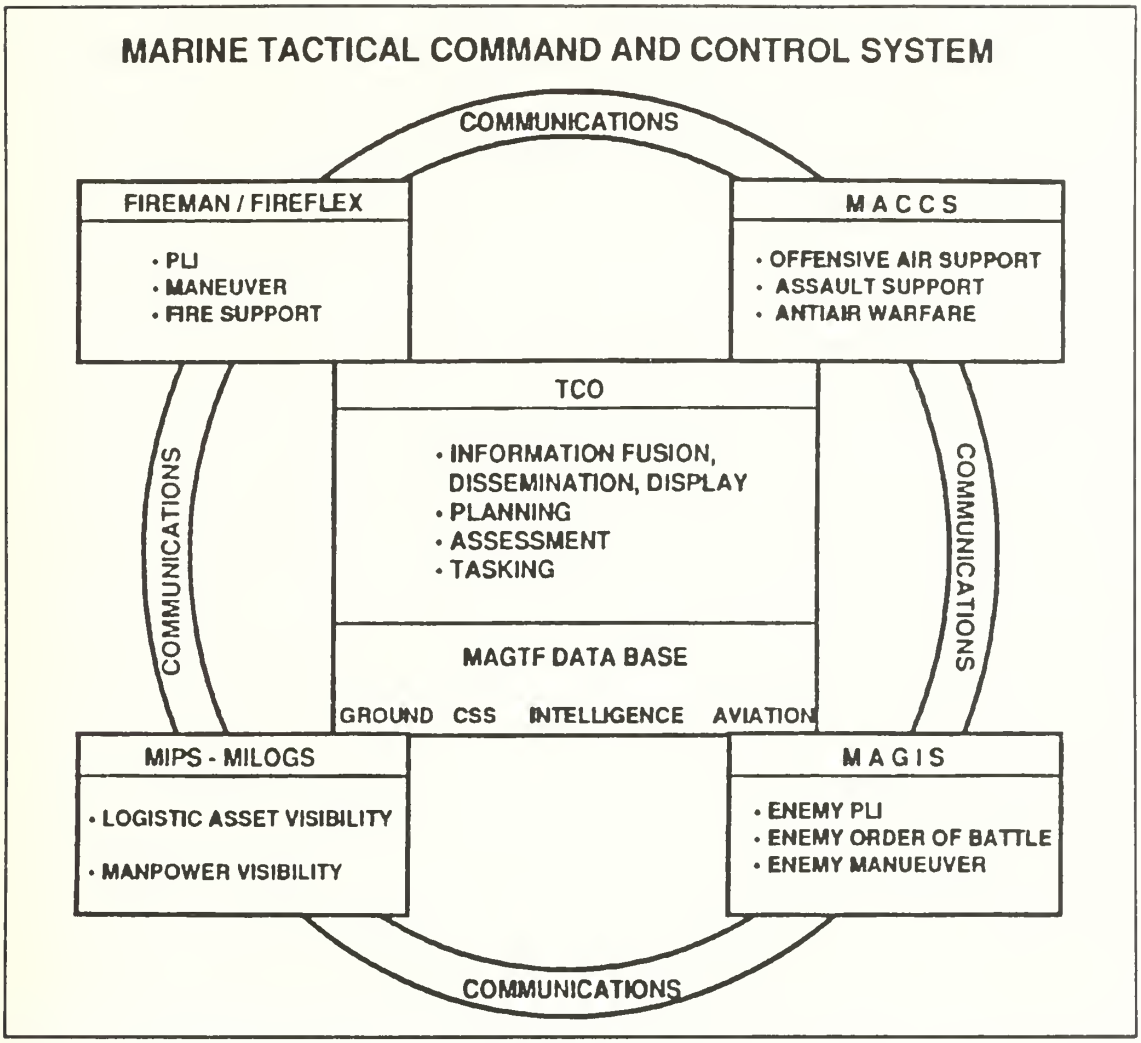

Figure 6: The MTACCS Concept [Source: MCCDC]

middle layers which consist of System Support Software and Command and Control Software and will be the foundation upon which MTACCS software will be built. System Support Software will provide a uniform development approach and will rely on Commercial-Off-The-Shelf Software (COTS) to the maximum extent possible. Command and Control Support Software will capitalize upon developments made by the Army's CASS program. The Command and Control Applications Software Layer will contain those common applications that provide common functionality across two or more MTACCS nodes. It will be comprised of software developed by Air, Ground, Intelligence, and Combat Service Support programs. These applications fall under the umbrella of MTACCS software which will facilitate communications between the various applications and provide an overall battle situation picture for the command and control facilities of the MTACCS.

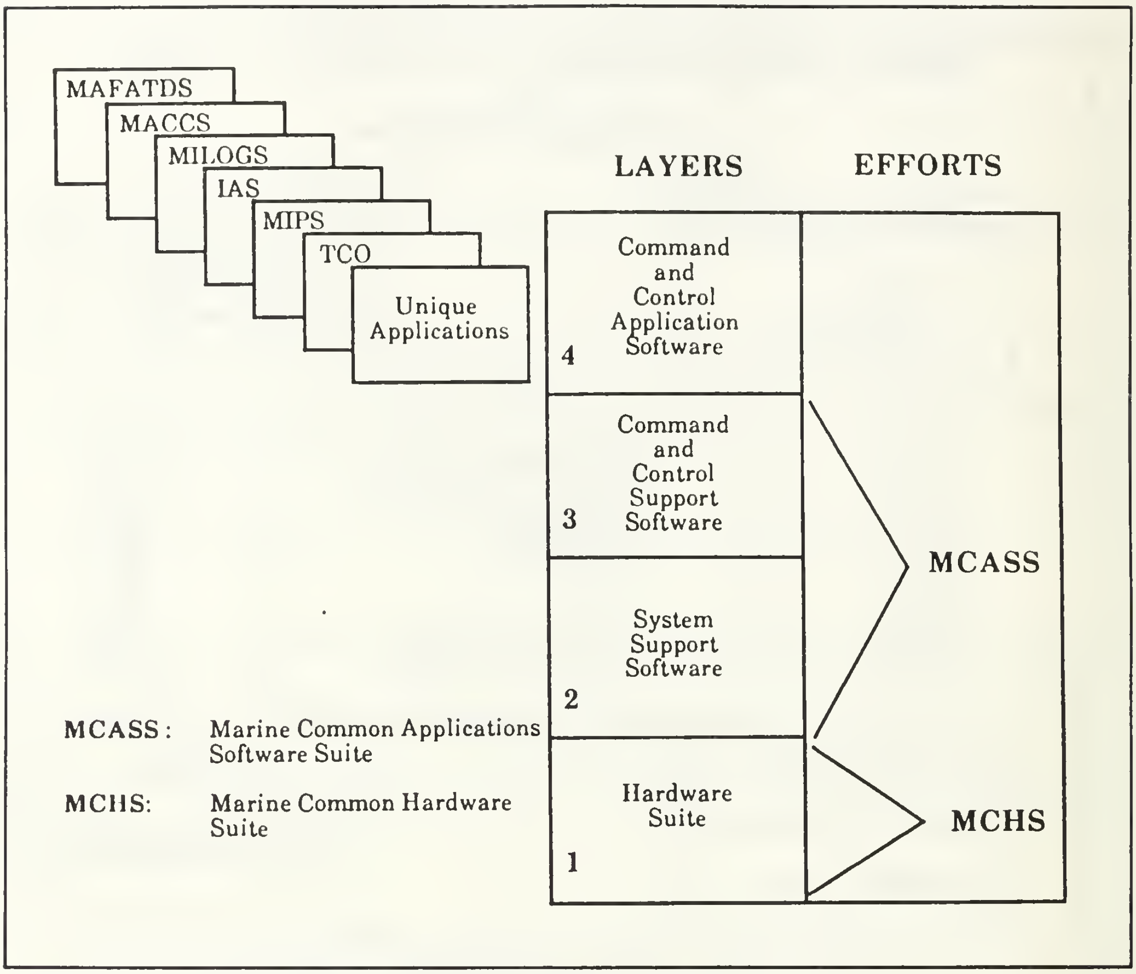

Figure 7: MTACCS Four Layer Architecture [Source: Ref. 34]

An important goal of the MTACCS philosophy is to develop common software for levels two and three, and common application software for each functional area at level four. The end result of the common building block approach for MTACCS is to lower development and production costs, enable common training and maintenance, lower support costs, reduce complexity, and increase interoperability. [Ref. 34:p 2.3-2.4]

C. THE CURRENT STATUS OF MTACCS COMPONENT SYSTEMS

1. MAGTF C^2

The capstone of MTACCS will be the system which provides integration of all the other component systems. At the current time, such a system does not exist,

although it is conceived to be a derivation of the Tactical Combat Operations (TCO) system. The TCO system is currently in the conceptual stage and will receive much of its definition through the Field Development System (FDS). [Ref. 2:p 1-6] The anticipated TCO development schedule is shown in Figure 8.

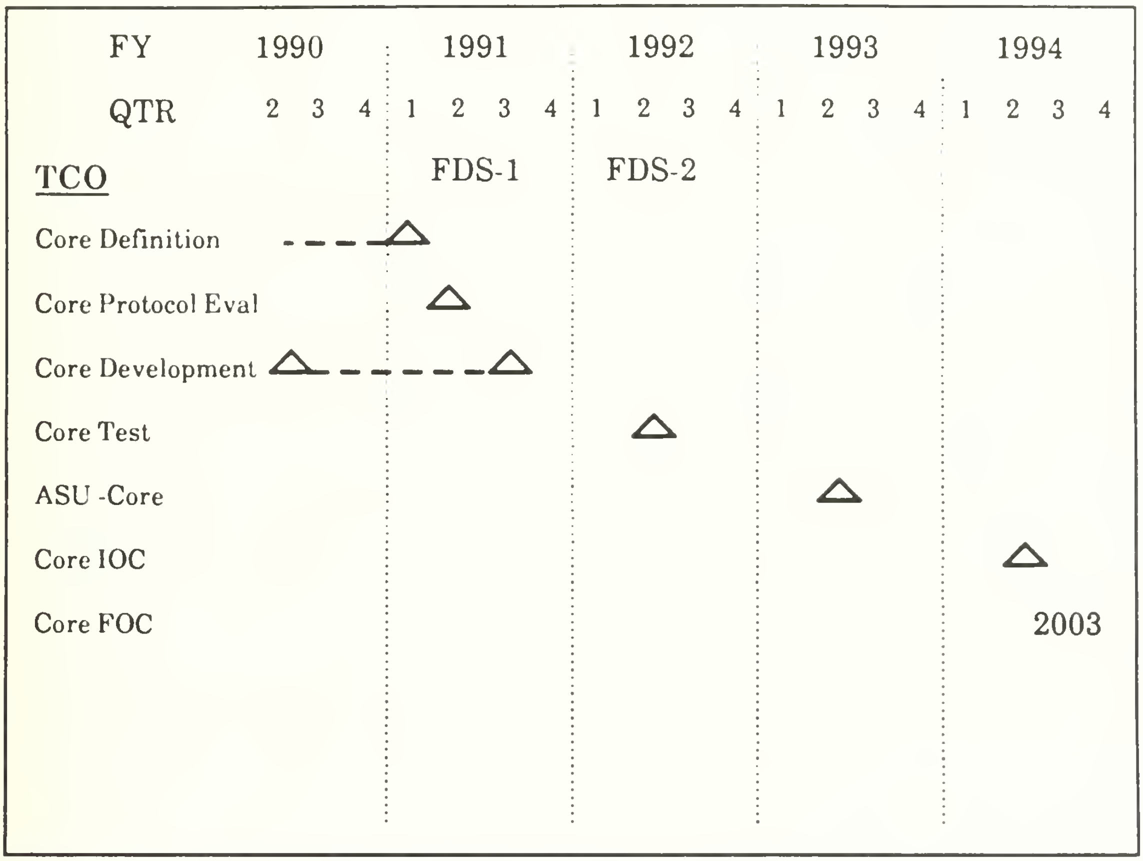

Figure 8: TCO Development Schedule [Source: Ref. 32]

TCO will provide MAGTF commanders at all echelons with specific tactical applications software programs which will build on common hardware and software. These applications will include tools such as:

1. Display of Position Location Information (PLI) extracted from PLRS/GPS systems.

2. Information on the friendly situation and resources extracted from the MIPS and MILOGS systems.

3. Information on the supporting arms situation extracted from the Multi-service Advanced Field Artillery Tactical Data System (MAFATDS) system.

4. Summary information on the enemy situation extracted from the MAGIS system. [Ref. 32:p B-1]

2. Ground C^2

The major component systems of Ground C^2 include the Tactical Combat Operations (TCO) system and the Multi-service Advanced Field Artillery Tactical Data System (MAFATDS). At this level, TCO will primarily support infantry, tank, engineer, and reconnaissance units while MAFATDS will support the fire support units (artillery, mortar, and naval gunfire). TCO is still in the conceptual stage. The focus of TCO will be the development of a common situation picture to support ground combat unit commanders and operations personnel. MAFATDS is a proposed adaptation of the Army Advanced Field Artillery Tactical Data System (AFATDS). AFATDS recently underwent a concept evaluation and is currently undergoing further development by the Magnavox Electronic Systems Company. [Ref. 2:p 1-6] The General Accounting Office reported in 1989 that:

> Fielding AFATDS...is scheduled for the fourth quarter of fiscal year 1992...the schedule appears to be optimistic considering the significant software development still required....[Ref. 5:p 13]

MAFATDS is expected to be fielded in the 1994 time frame. Currently, Fleet Marine Force (FMF) units have an interim system, FIREFLEX, which will be used until

MAFATDS becomes available. [Ref. 2:p 1-6] The anticipated MAFATDS development schedule is shown in Figure 9. [Ref. 32:p B-2]

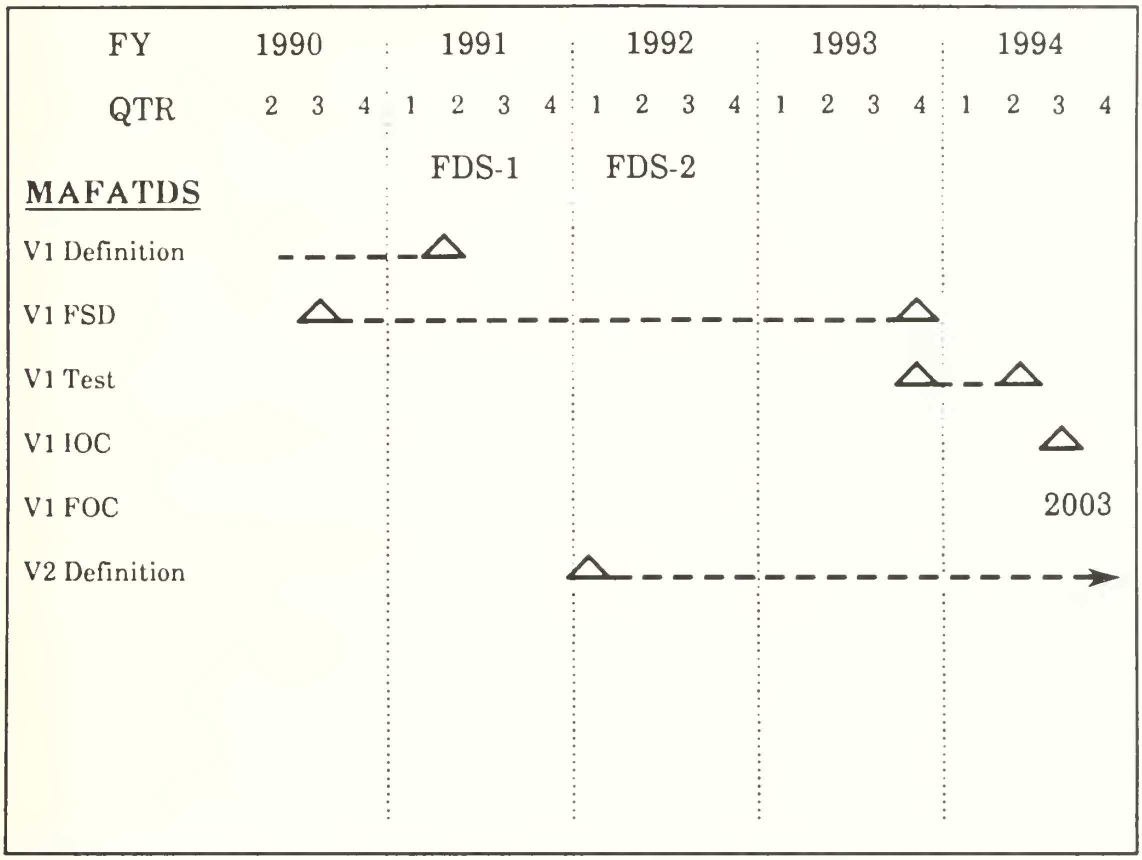

Figure 9: MAFATDS Development Schedule [Source: Ref. 32]

3. Aviation C^2

The major component systems of Aviation C^2 include the Advanced Tactical Air Command and Control Central (ATACC), the Tactical Air Operations Module (TAOM), the Improved Direct Air Support Center (IDASC), and the Marine Air Traffic Control and Landing System (MATCALS). [Ref. 2:p 1-7]

ATACC is being developed to support the operations and planning functions of the Tactical Air Command Center (TACC), the senior Marine aviation combat

operations center in the MAGTF. The TACC exercises command over MAGTF air operations, generates daily air tasking orders, plans the air campaign, and is the principle MAGTF interface with joint and combined C^2 agencies [Ref. 32:p B-3]. ATACC is scheduled to be available in 1992 [Ref. 2:p 1-7]. The anticipated ATACC development schedule is shown in Figure 10.

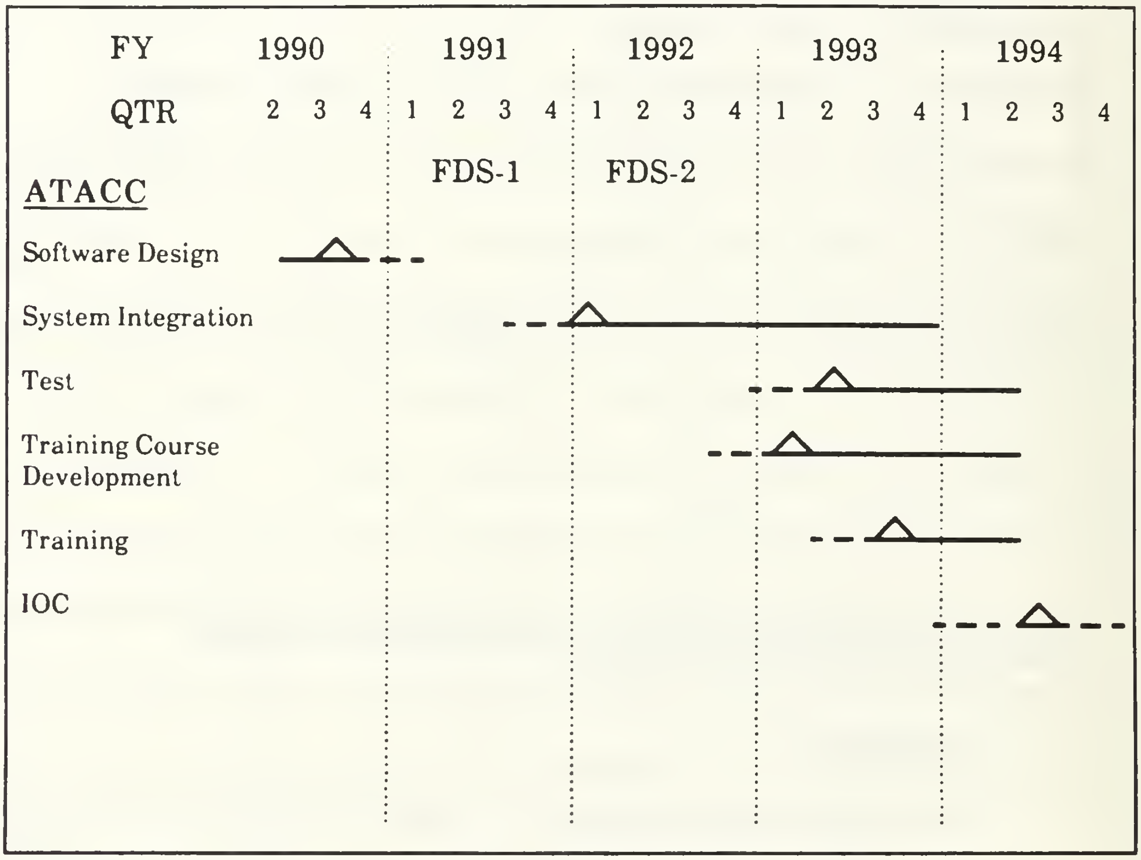

Figure 10: ATACC Development Schedule [Source: Ref. 32]

TAOM is currently in production and has been designated to replace the AN/TYQ-2 and AN/TYQ-3A[15] at the Tactical Air Operations Center. TAOM is capable

[15] The AN/TYQ-2 and AN/TYQ-3A are communications and computer components of the TAOC.

of performing all operational air defense tasks and is currently deployed in Saudi Arabia in support of Operation Desert Storm.

IDASC is designed to support the Direct Air Support Center (DASC) tasks of coordinating assault support, close air support strikes, and air reconnaissance missions with other fire support means. The DASC product improvement program will incorporate selected automation measures to improve system performance. Phased improvements to IDASC include:

1. Electronic mapping capability, i.e., replacement of paper map-manual plot with electronic projection map and electronic automated assistance (computer) plot.

2. Status board automation, i.e., replacement of plexiglass status boards (one dealing with fixed wing and the other with rotary wing) and manually transcribed data information/updates with electronic displays at appropriate operator stations (fixed wing status display/rotary wing status displays) and electronic automated assistance input control devices (computers) to control fixed and rotary wing status input/display.

3. Automation of the Air Tasking Order (ATO) to include receipt, dissemination, update, etc.

4. Automation assistance for receipt of digital (DCT type) messages (Tactical Air Requests (TAR), Helo Requests (HR), etc.)

5. Automatic incorporation of Position, Location, Reporting System (PLRS) data into the DASC electronic map/projection system.

6. Automated assistance in journaling, recording traffic, printing, etc.

7. Downsizing (transitioning to lighter equipment and smaller mobile shelters). [Ref. 2:p 1-7]

The product improvement schedule is shown in Figure 11.

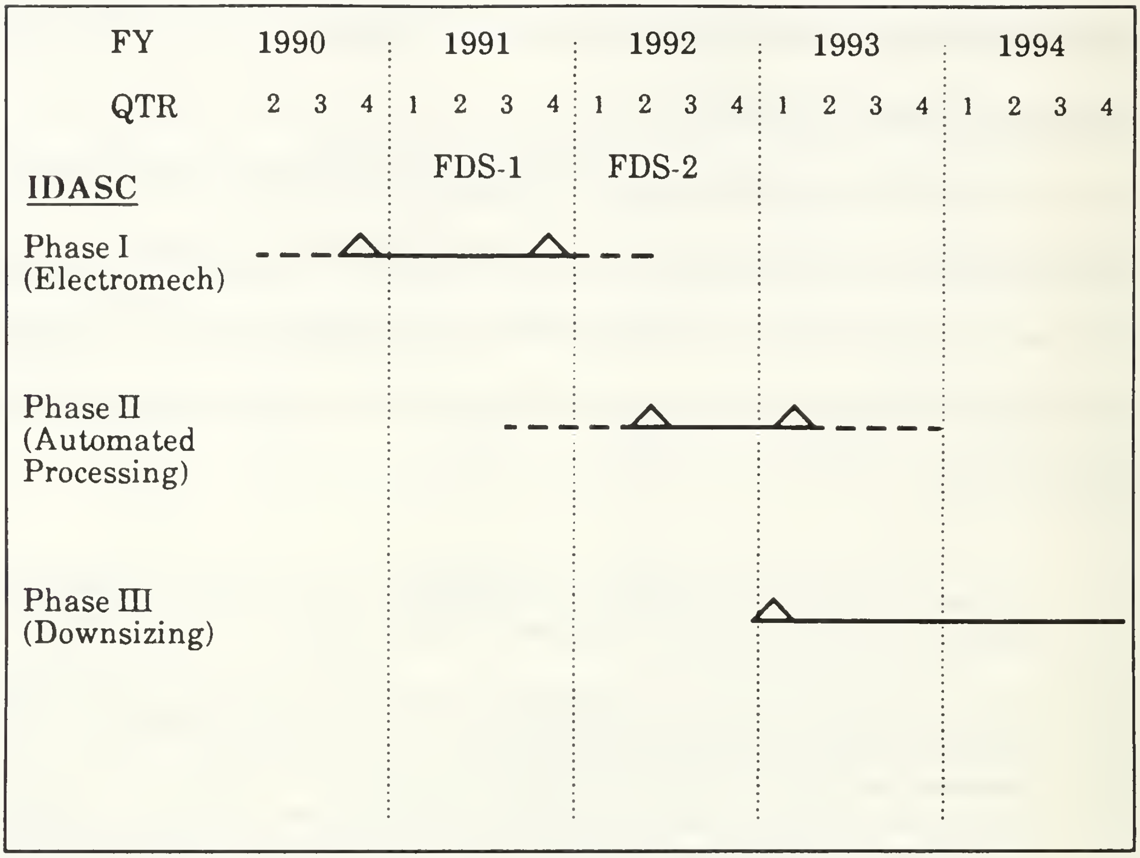

Figure 11: IDASC Product Improvement Schedule [Source: Ref. 32]

4. Combat Service Support C²

The major component subsystems of Combat Service Support C² include the Marine Integrated Personnel System (MIPS), the Marine Integrated Logistics System (MILOGS), and the Improved Force Automated Services Center (IFASC) [Ref. 2].

MIPS will provide the FMF commanders essential near real time personnel information through its interface with TCO. MIPS will employ the Unit Commander's Personnel System (UCPS) as the source of data to provide to TCO and the MAGTF C² system. UCPS is currently available and being used by FMF units. The MIPS interface

with UCPS and TCO is conceptual and will be developed throughout the FDS series. [Ref. 2] The MIPS anticipated development schedule is shown in Figure 12 [Ref. 32:p B-5].

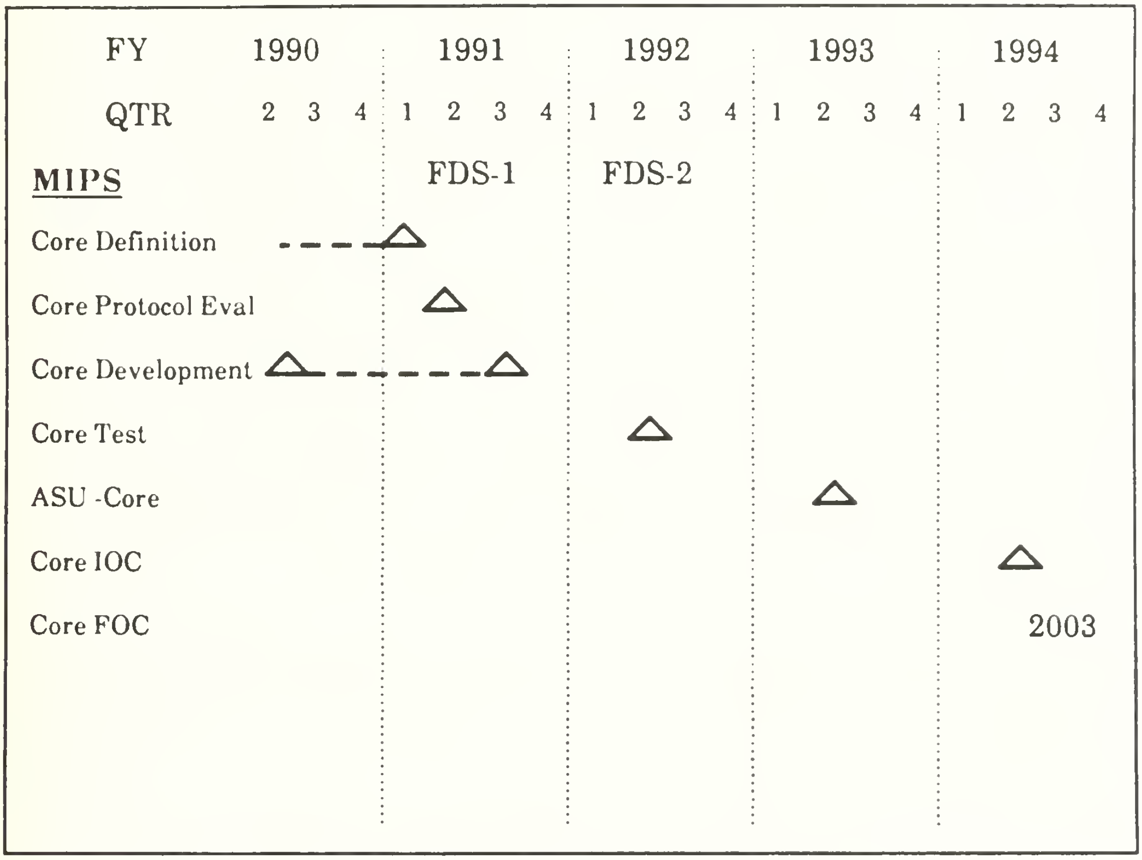

Figure 12: MIPS Development Schedule [Source: Ref. 32]

MILOGS will employ the LOG II AIS[16] systems and integrate their output to provide the information required by TCO and the MAGTF C^2 system. LOG II AIS systems currently exist and are being used within FMF units. The MILOGS interface with LOG II AIS and TCO is also conceptual and will be developed throughout the FDS series. The ongoing U.S. Army Combat Service Support Control System (CSSCS)

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[16] The second generation automated logistics information system.

development is being closely monitored. Maximum advantage of Army development efforts will be taken in defining and developing MILOGS and will be incorporated into the FDS series. It is anticipated that the CSSCS development schedule will not permit the use of CSSCS functionality in FDS 1. [Ref. 2:p 1-7] The anticipated MILOGS development schedule is shown in Figure 13 [Ref. 32:p B-5].

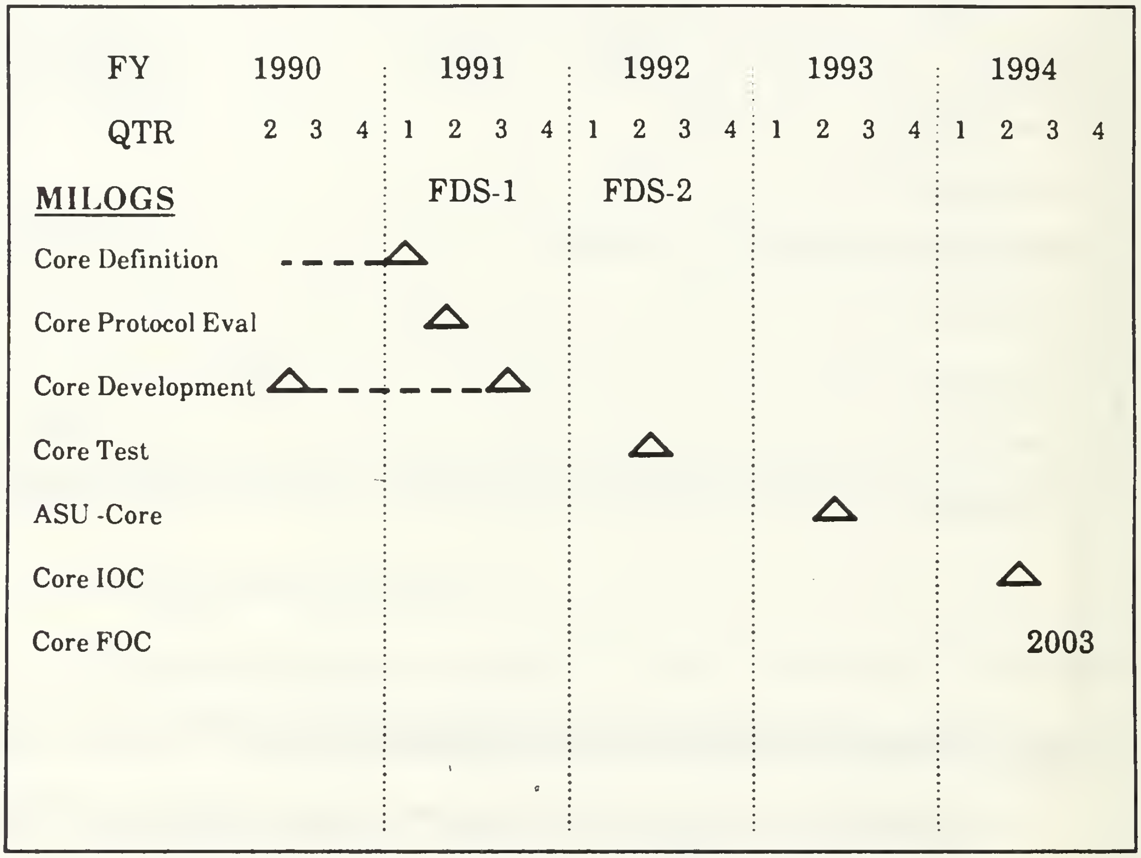

Figure 13: MILOGS Development Schedule [Source: Ref. 32]

5. Intelligence

The Intelligence Analysis System (IAS), currently under development, will be incorporated into FDS 1 and following FDS events as appropriate. Interfacing to the IAS will be facilitated for FDS 1 since the computer hardware, tools, etc., upon which the IAS

are hosted are the same basic building blocks that will be utilized for TCO, MIPS, and MILOGS. IAS serves as the fusion center for the multiple intelligence sources available to the MAGTF.

Intelligence systems and agencies that provide input to the Intelligence Analysis System/Intelligence Analysis Center (IAS/IAC) are shown in Figure 14. Included are the Technical Control and Analysis Center (TCAC), Tactical Electronic Reconnaissance Process and Evaluation System (TERPES), Topographic platoon, Reconnaissance units (Force and Division), the Imagery Interpretation Facility (IIF), Imagery Processing (IP) segment, Remotely Piloted Vehicle (RPV) system, Interrogator Translator Teams (ITT), Counter Intelligence Teams (CIT), Joint Service Imagery Processing System (JSIPS), Remote Ground Sensors/Tactical Remote Sensor System (RGS/TRSS).

The interaction between IAS and TCO is conceptual at this time and will be defined and developed during the FDS series. [Ref. 2:p 1-7] The anticipated IAS block upgrade development schedule is shown in Figure 15. [Ref. 32:p B-4].

6. Communications

The MTACCS Master Acquisition Plan identifies several communications systems that are of vital importance to the success of MTACCS:

1. AN/PSC-2 Digital Communications Terminal (DCT). A light weight, handheld, programmable message processor that plugs into standard Marine Corps Radios.

2. Position Location Reporting System (PLRS). A system of digital UHF radios that will automatically provide commanders with accurate, near real time identification and location data on assigned forces.

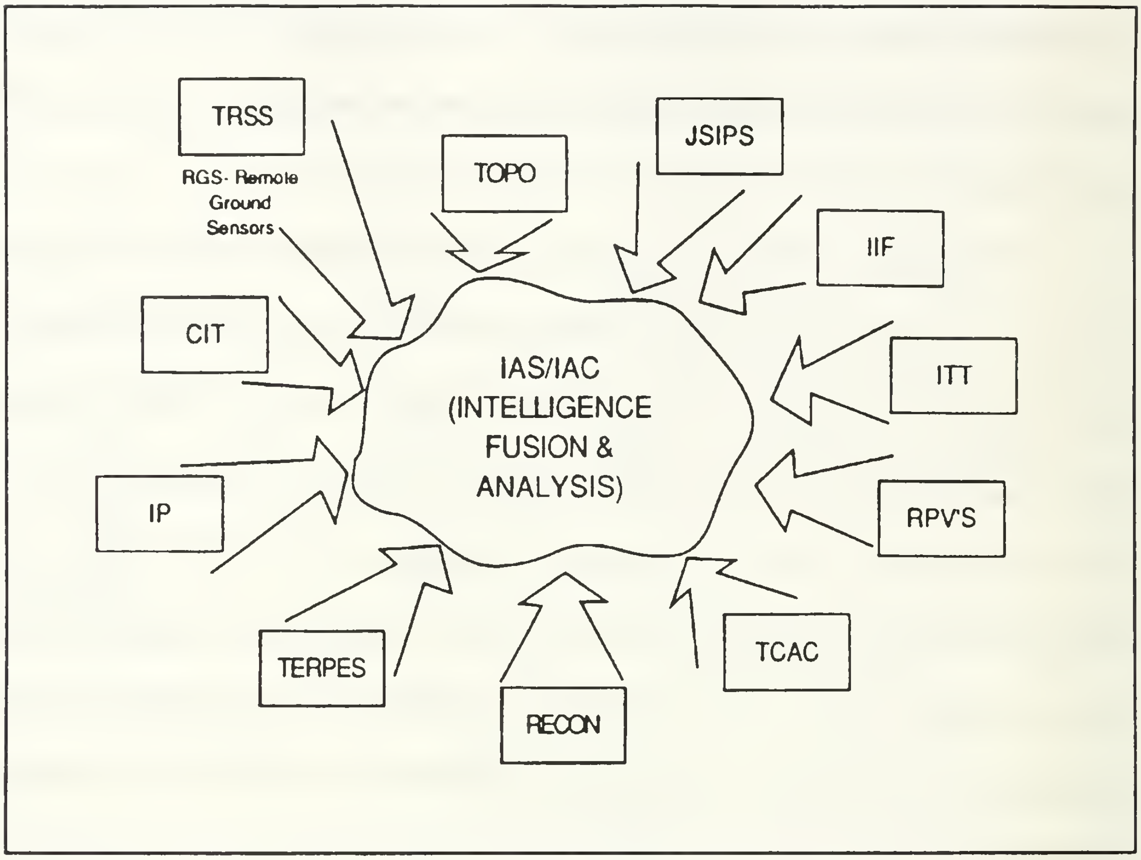

Figure 14: Marine Air/Ground Intelligence Systems [Source: Ref. 32]

3. Global Positioning Systems (GPS). A spaced based radio navigation system that provides position, velocity, and time.

4. Unit Level Circuit Switch (ULCS). A family of digital equipment that provide automatic switching service and subscriber service functions.

5. Unit Level Tactical Data Switch (ULTDS). A team transportable, 12 line data switch.

6. Single Channel Ground Air Radio System (SINCGARS). A VHF-FM single channel, frequency hopping radio used to transmit voice and data.

7. AN/MRC-142. A secure, VHF, digital, multichannel radio for voice and data.

8. AN/TRC-170. A SHF troposcatter multichannel radio. [Ref. 21]

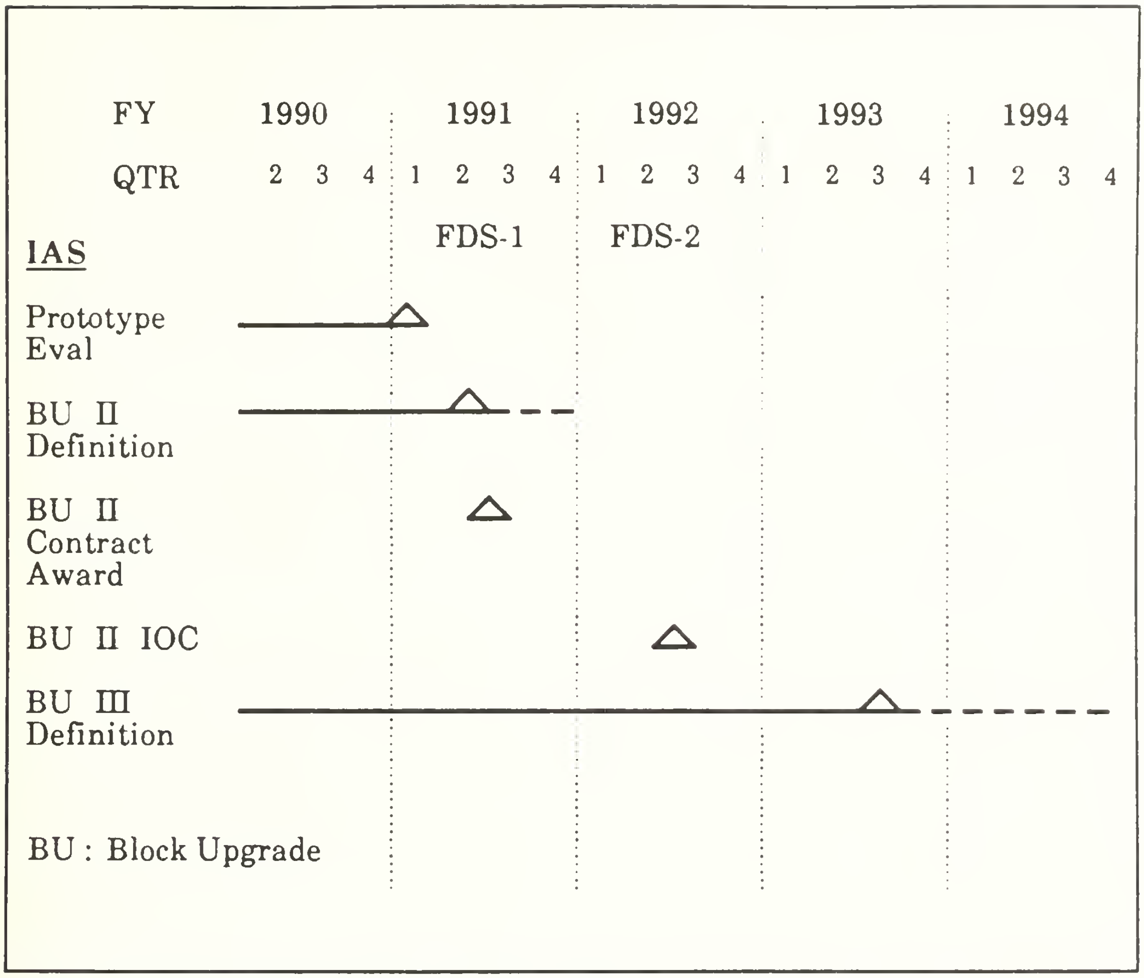

Figure 15: IAS Development Schedule [Source: Ref. 32]

All but the ULTDS are in production. These systems are intended to provide the necessary communications throughput to sustain at least early versions of MTACCS. It is recognized that the capabilities of these systems may be exceeded as the MTACCS integration matures.

The anticipated communications architecture is shown in Figure 16.

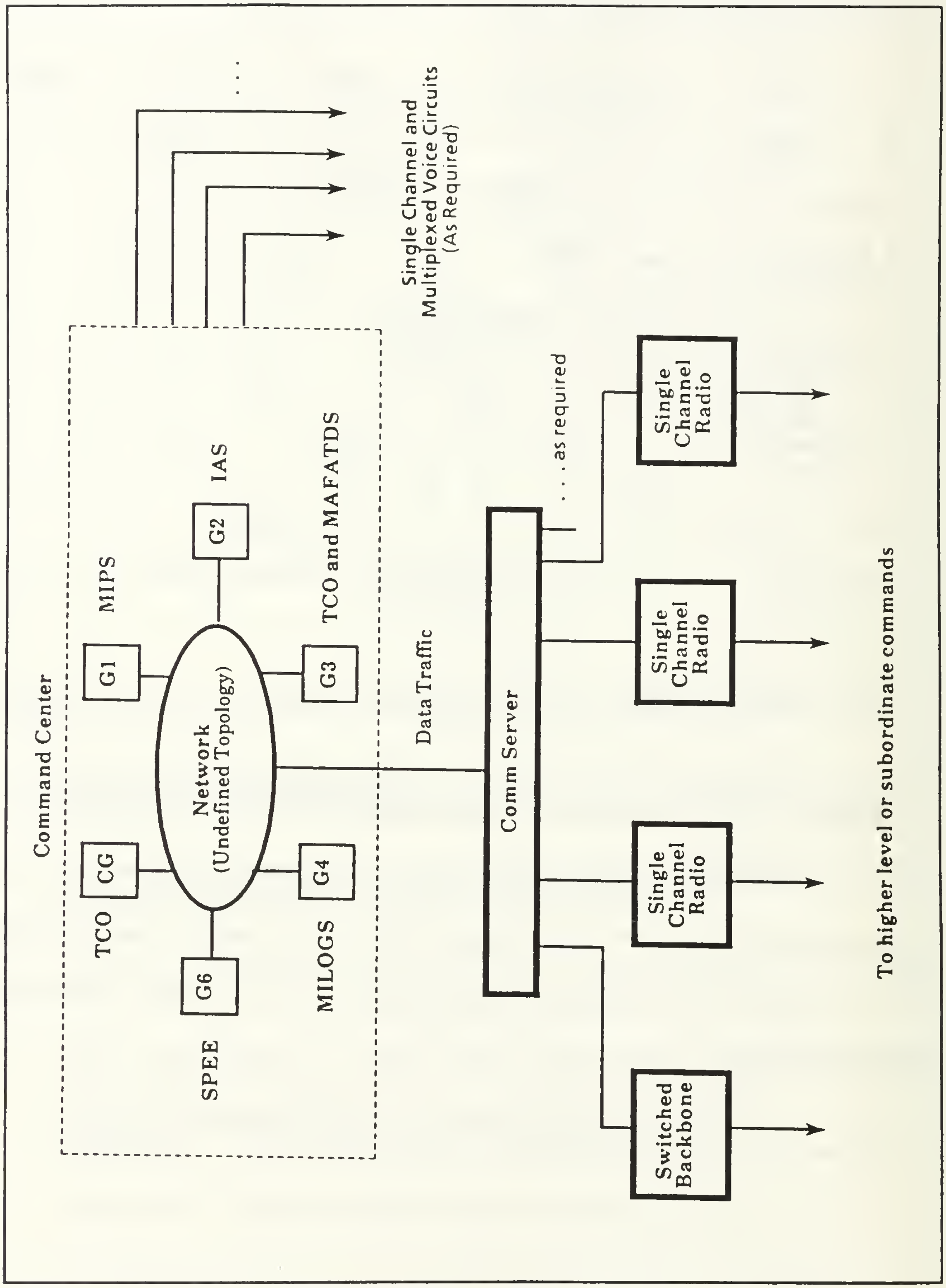

Figure 16: MTACCS Communications Architecture [Source: Ref. 34]

D. THE FIELD DEVELOPMENT SYSTEM (FDS)

1. Background

MTACCS was defined earlier as an "engineering effort" intended to accomplish, among other objectives, management of the integration of MTACCS component systems. The Field Development System project is a key component of that engineering effort.

The Field Development "System" would perhaps be better described as a "process" or "methodology". FDS is based on promoting a strong working relationship between the FMF user, Marine Corps developers, and private industry. [Ref. 35:p iii] It is a strategy for including the user in the process of identifying and validating requirements for an integrated command and control automated support system. Figure 17 details the FDS approach. As shown in Figure 18, FDS will be a series of events. Specific goals will be established for each FDS event. During that event, the available version of all component subsystems will be brought to the FDS site. The systems will be integrated to the level necessary to achieve the objectives of that event. Once those objectives are achieved and the system is evaluated to be ready, a working, integrated system is delivered to the fleet users. Colonel Michael Stankosky, the current deputy program manager for MAGTF Command and Control Systems, feels that the evolutionary design of the system will allow the Marine Corps to deploy basic versions of MTACCS early on. Information from field testing will help designers overcome errors and technical difficulties by gradually building upon successes. [Ref. 20:p 27] The Marine Corps Tactical Systems Support Activity (MCTSSA) at Camp Pendleton,

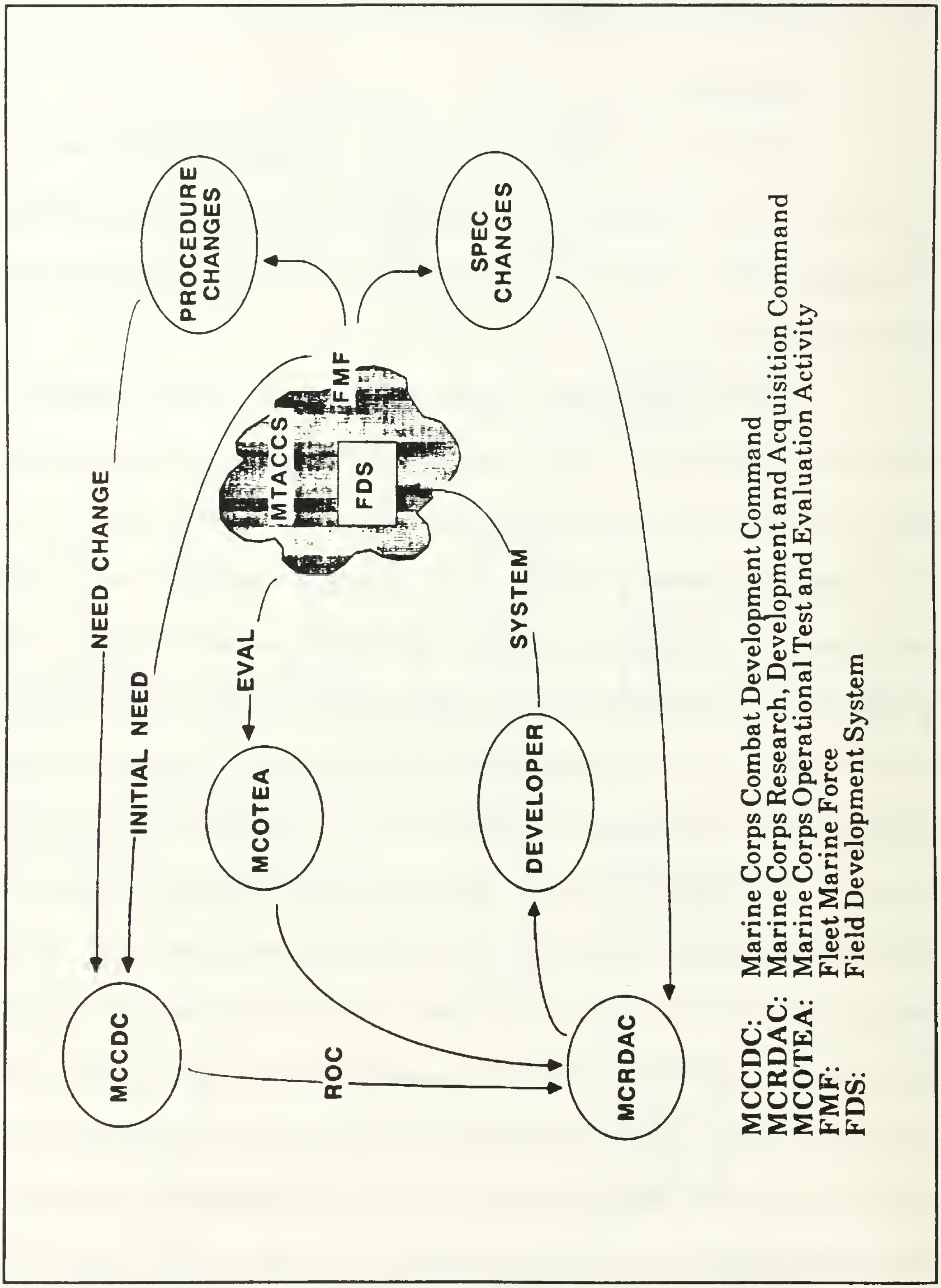

Figure 17: FDS Approach [Source: Ref. 32]

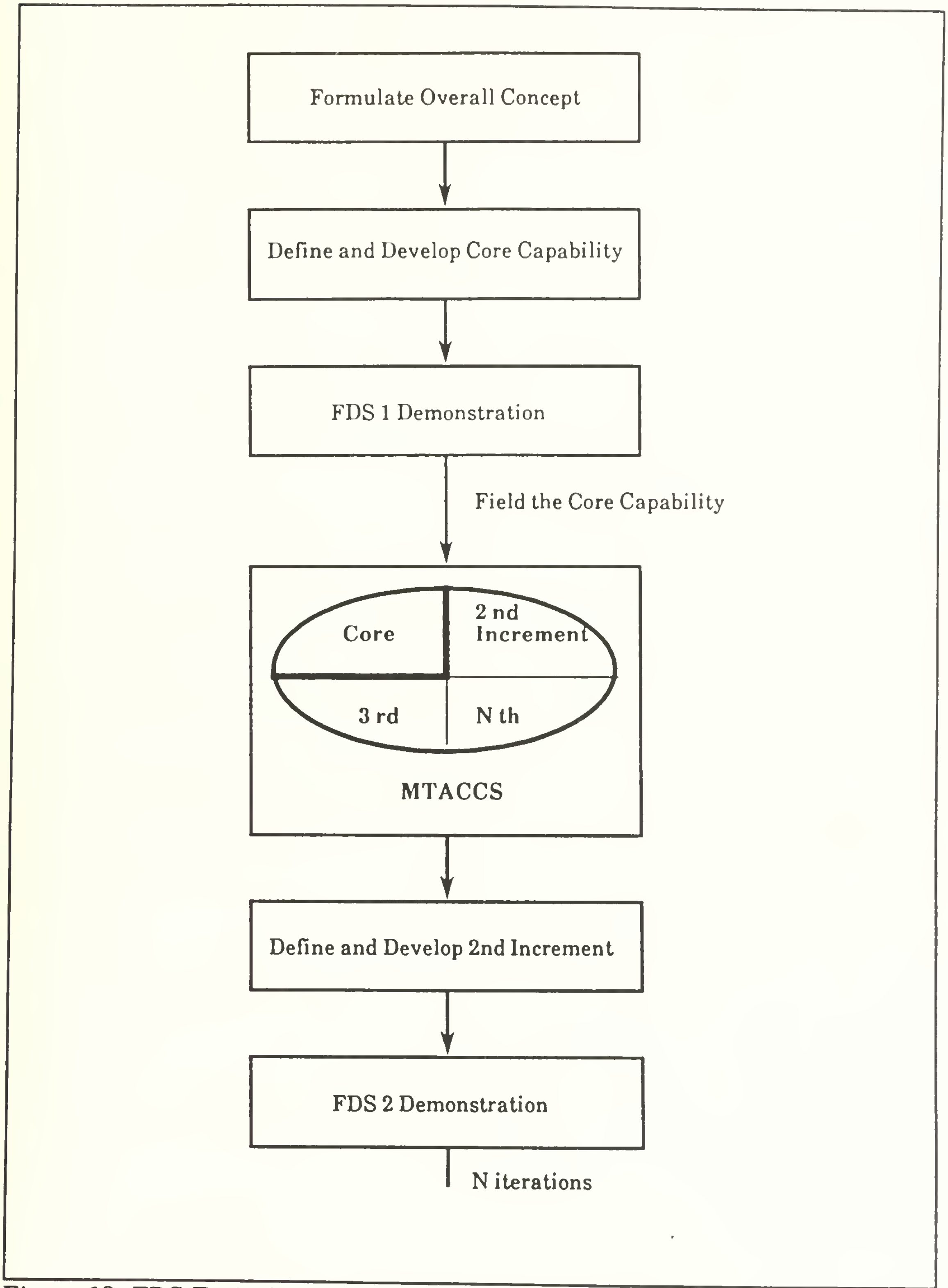

Figure 18: FDS Evolutionary Strategy [Source: Ref. 32]

California, has been selected as the site for the first event, FDS 1, scheduled to be conducted in early 1991 [Ref. 2].

2. Guidance Framework

In order to assure long term value and consistency between each Field Development System event, a Guidance Framework has been established prior to initiation of FDS 1. Key elements of the Guidance Framework are:

1. Common software foundation from industry as the baseline information system architecture.
2. Initial command software functionality for FDS 1 to include suitable items from emerging USMC programs.
3. Leverage from industry hardware specifically to support USMC requirements.
4. Application and integration software development only as deemed essential to furnish the required command software functionality to be addressed in each FDS.
5. Provide a consistent, but evolving system framework to support embedding disparate components and subsystems each with their various schedules and maturities.
6. Institute direct FMF involvement and direction in the sequential and open system development environment.
7. Provide an evolving system platform for developing interoperability approaches and resolving issues.
8. Provide system support for examining technologies prior to selection and/or funding for inclusion in subsequent FDS phases. [Ref. 2:p ii]

3. Operational Concept

The overall operational objective of FDS 1 is to provide operational personnel within the MAGTF with a set of automated tools and techniques that will assist them in performing already established C^2 functions. These functions have already been documented and proven over the years and are an accepted part of the command and staff process. Functionally, FDS 1 will put in place a system that will provide automated capabilities to commanders and staff officers in performing these doctrinal functions.

In support of these objectives, the operational concepts employed in FDS 1 are simple. WHAT functions are performed and by WHOM will not be affected by FDS 1, only HOW the function is accomplished. What this means is that FDS 1 will concentrate on providing commanders and staff officers automated assistance in the form of computers, electronic displays, and digital communications to perform functions they are now performing manually.

In this regard, FDS 1 will not initially try to achieve a wide range of "operational functionality" to support C^2 personnel, but rather will focus its efforts on putting the basic support functionality in place that will enable simple operational functions to be performed using automated equipment. The scope of the operational functionality will be incrementally expanded in future FDS phases to include all required command and staff functions deemed appropriate for inclusion in MTACCS.
[Ref. 2:p 1-9]

4. Generalized Objectives

The generalized objectives to be achieved at each FDS phase are:

1. Present to users a functioning entity, not just disconnected technologies.
2. Demonstrate leverage from available system components.
3. Provide increasing experience and guidance opportunities in the growth of C^2 automated assistance.
4. Provide fieldable system segments for USMC units.
5. Build an evolving working model of MTACCS.
6. Build models so that some enduring value is achieved at each FDS phase.
7. Institutionalize a development approach that will enhance alignment with requirements and accelerate the delivery of capability to the field.
8. Institutionalize a development approach that will facilitate integration of disparate developing technical subsystems. [Ref. 2:p iii]

E. THE NEW MARINE CORPS ACQUISITION ORGANIZATION

1. The Goldwater-Nichols Reorganization Act

The Goldwater-Nichols Reorganization Act "requires the military departments to designate a single office or entity in each secretariat to conduct acquisition functions to eliminate the parallel or duplicate acquisition offices that had existed in both secretariats and the services' Chief of Staff organizations". [Ref. 26:p 2] This same guidance was applied to the acquisition organization within the Marine Corps.

The Marine Corps complied with this act by creating two new commands: the Marine Corps Combat Development Command (MCCDC) and the Marine Corps

Research, Development, and Acquisition Command (MCRDAC). The Marine Corps Development and Education Command (MCDEC) was eliminated and its functions were distributed between the two new commands.

> Prior to this reorganization, acquisition responsibilities were divided among several headquarters activities. Most of the acquisition functions previously conducted by several different departments and divisions in Marine Corps Headquarters were centralized into the newly formed Research, Development, and Acquisition Command. [Ref. 9:p 54]

2. The Marine Corps Combat Development Command (MCCDC)

MCCDC has the responsibility of refining requirements that are identified by the Fleet Marine Force (FMF). Requirements may be satisfied through changes in doctrine, structure, tactics, or equipment. The Commanding General of this command assesses the FMF requirement in order to validate the need for the acquisition of equipment. If new equipment is needed to satisfy the requirement, the Warfighting Center (a component within MCCDC) publishes a statement of Required Operational Capability (ROC). The Commanding General of the Marine Corps Research, Development, and Acquisition Command uses this ROC as the basis to acquire the new equipment. [Ref. 27:p 30]

The Marine Corps Systems Acquisition Management manual lists specific responsibilities of the Commanding General of MCCDC. These responsibilities include:

1. Develop concepts, plans, and doctrine.
2. Identify requirements for changes to doctrine, training, MAGTF force structure, and material.
3. Serve as the MAGTF proponent. [Ref. 26:p 3-21]

The organization created to accomplish these tasks is depicted in Figure 19.

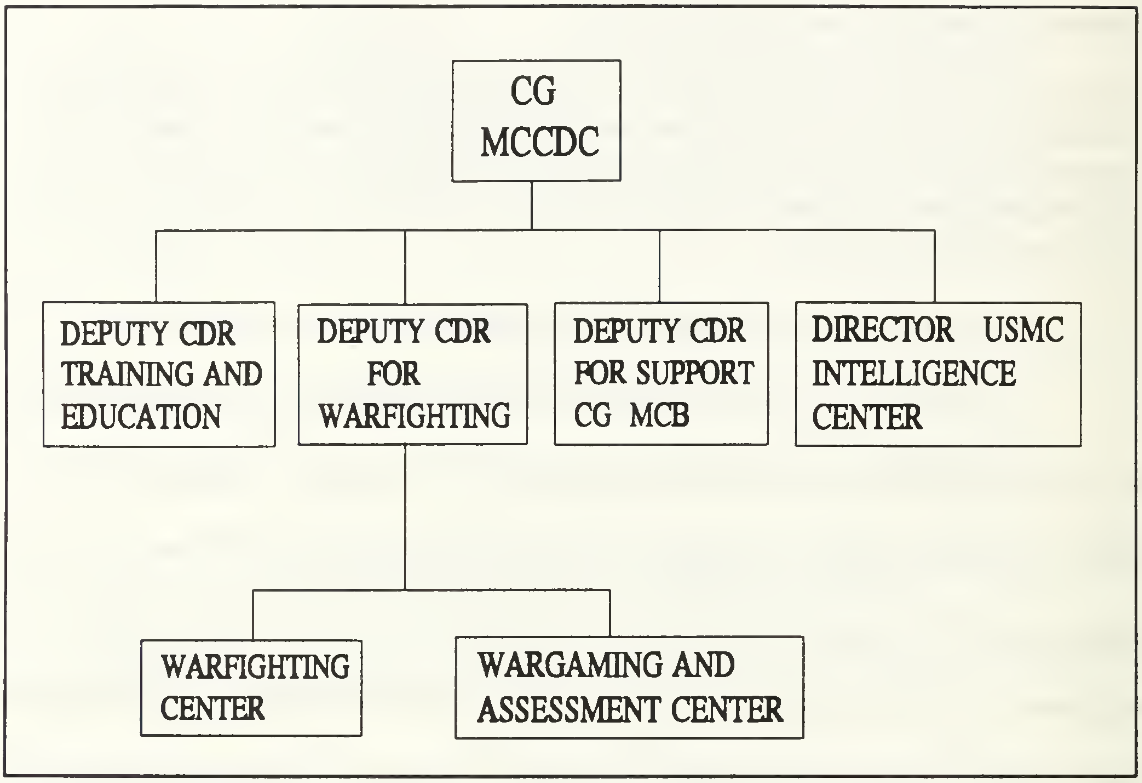

Figure 19: MCCDC Organizational Diagram [Source: MCCDC]

3. The Marine Corps Research, Development, and Acquisition Command (MCRDAC)

The Marine Corps Systems Acquisition Management Manual describes the responsibilities of MCRDAC as follows:

> The Commanding General of MCRDAC is the Marine Corps Program Executive Officer (PEO). As such he has the responsibility, authority, and accountability for all Marine Corps acquisition programs in accordance with Public Law 98-94 (Goldwater-Nichols Reorganization Act) ... [Ref. 26:p 3-13]

The Program Executive Officer (PEO) is defined by the Secretary of Defense, Dick Cheney, in his 1989 report to the President on defense management. In that report,

the PEO is described as a key middle manager responsible to the Service Acquisition Executive (SAE) for defined and limited groups of major programs. The PEO will have a small, separate staff organization and devote full time attention to management of assigned programs and related technical support resources. [Ref. 36:p 9] The streamlined acquisition organization mandated by the Defense Management Review is shown in Figure 20. This streamlined approach was instituted with the intention of establishing clear command channels for the acquisition of new systems. An extract of the MCRDAC organizational diagram is shown in Figure 21.

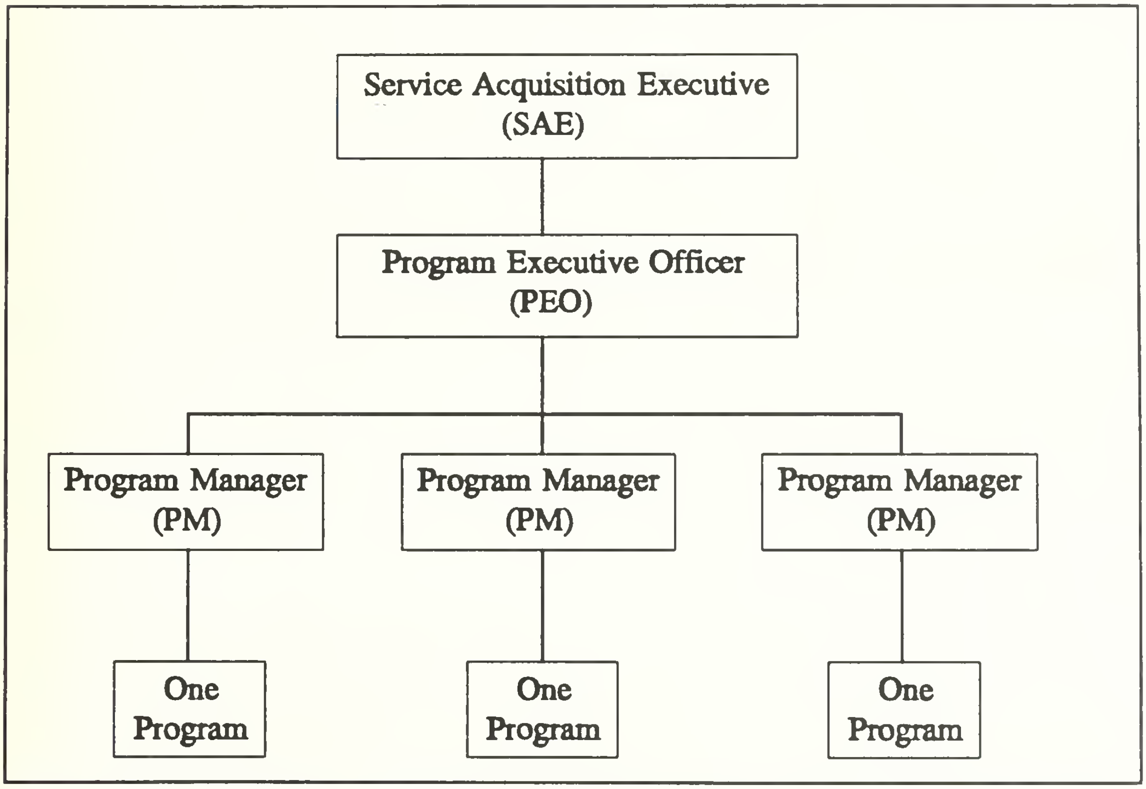

Figure 20: Streamlined Acquisition Approach for Major Programs [Source: Authors]

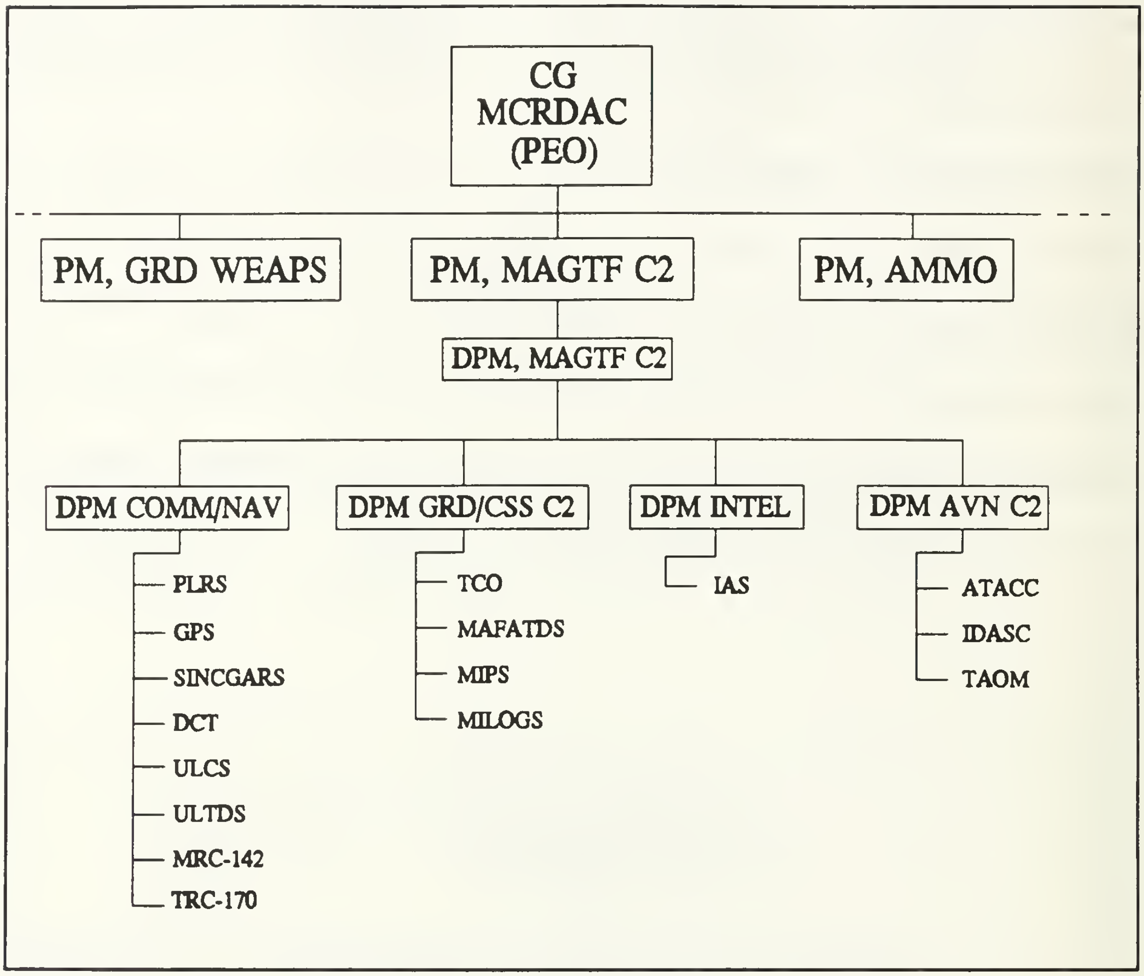

Figure 21: MCRDAC Organizational Diagram [Source: Ref. 26]

The Commanding General of MCRDAC assigns program managers and issues their charters. "The charter is a memorandum of understanding between the program manager and his superiors" [Ref. 37:p 2-6]. It details the precise scope of the program manager's responsibility and authority [Ref. 37:p 2-5].

> The appropriate program manager takes the validated ROC and turns it into a reality. The Commanding General of MCRDAC has the authority for overall MTACCS acquisition policy, accountability for acquisition execution, and clear lines of command for program managers... He has designated the program manager for Marine Air Ground Task Force (MAGTF) Command and Control as the focal point for MTACCS [Ref. 27:p 30]

Program managers have full authority, responsibility, and accountability for their programs. They report directly to the Program Executive Officer (PEO) for all programmatic matters, and are assigned the full authority of the PEO for the centralized management of specified acquisition programs. [Ref. 26:p 3-16]

The Marine Corps Systems Acquisition Management Manual lists thirty five specific responsibilities of the Commanding General of MCRDAC. These responsibilities include:

1. Advises the Commandant on Marine Corps acquisition policy.

2. With the Commanding General MCCDC, coordinates the implementation of Joint Service Programs (JSP) and Other Service Programs (OSP).

3. Implements DOD/DON/USMC systems acquisition policy.

4. Provides input into the PPBS for acquisition and RDT&E.

5. Provides guidance to Program Managers in managing the business, financial, and technical aspects of assigned programs.

6. Represents acquisition programs to HQMC, DON, OSD, and the Congress.

7. Advises the Commandant at acquisition decision milestones and coordinates a number of review committees.

F. SUMMARY

Several problem areas were identified by the Marine Corps during the MIFASS era. Efforts to solve those problems have been extensive. The main thrust of these efforts has concentrated on a major reorganization of the Marine Corps development and acquisition team and a dedication to the strategy of Evolutionary Acquisition. The remainder of this thesis examines these solutions in detail. The objective is to develop an understanding

of the strengths and the possible risks inherent in both the MTACCS concept and the proposed solutions to long standing problems.

IV. A FEASIBILITY ASSESSMENT

A. THE NEED TO QUESTION FEASIBILITY

Since its inception, MTACCS has been considered to be a bold, farsighted concept. Developing a fully operational, effective command and control system of this scope will pose a major challenge to the Marine Corps. The risk of failure is significant. While supporters of the MTACCS concept are optimistic, there is considerable precedent to cause concerns; concern that the system may not be compatible with current doctrine; concern that the objectives may not even be technically possible at any reasonable cost. There must be, at the very outset, an assessment of the feasibility of this project.

For the purpose of this thesis, feasibility is defined as the satisfaction of the following general criteria. To be feasible, MTACCS must be:

1. Compatible with current doctrine and established procedures.
2. Technically possible.
3. Limited in complexity, not the most sophisticated system imaginable.
4. Procured with an effective acquisition strategy.

While these criteria have been chosen based on subjective determination, there is little doubt that they represent a collection of common sense factors vital to the success of the MTACCS project.

Many risk factors have already been identified and addressed within the draft MTACCS Master Acquisition Plan (MAP). Some risk factors, however, have not been presented. Others have been acknowledged, but not yet thoroughly explored. The effort of this chapter will be on developing a complete understanding of the risks involved in developing this command and control system in order to evaluate the likelihood of success.

Much of the question of feasibility centers on risk analysis. Defining the idea of "risk" is crucial to this assessment. Several factors have been identified to qualitatively measure risk:

1. To what degree is the anticipated technology available now?
2. What is the extent of user advocacy?
3. How well are the tasks involved defined and understood?
4. What is the stability of the mission and the environment?
5. What is the expected length of time to develop needed technologies?
6. Are the procurement strategies tested? Appropriate?

While this list is not exhaustive, these factors will provide some of the basis for determining how much risk is involved in meeting each of the feasibility criteria.

B. THE FEASIBILITY CRITERIA

1. MTACCS must be Compatible with Current Doctrine and Established Procedures

The warfighting doctrine of the United States Marine Corps provides the authoritative basis for the conduct of war by Marine forces. While authoritative, doctrine is not prescriptive [Ref. 38:p 44]. In the broad sense, doctrine is the foundation for the development of organizations and procedures. The command and control system includes these organizations and procedures as well as the communications and computers of automated decision support systems. It has been decided from the outset of the program that the MTACCS effort will not change current MAGTF staff and unit organizations [Ref. 32:p 3]. The doctrine that is the basis of the organization must be complimented by the concept that defines the decision support systems.

> It is a frequently cited axiom of systems analysis that information models the organization. An information system should model the structure of the organization. [Ref. 39:p 57]

2. MTACCS must be Technically Possible

There is no doubt that the technical integration of numerous disparate automated systems across the entire spectrum of the battlefield will be a complex problem. There are many questions that must be answered as development of the MTACCS concept proceeds. The MTACCS Operational Concept implies several technical requirements. Among these are:

1. Multi-level security.

2. Extensive data communications.

3. Real time or near real time processing capability.

4. Challenging software development.

The technical feasibility of these requirements is difficult to assess. There are implied requirements that have not yet been completely defined. Still, a technical assessment can be made to develop an understanding of the general level of difficulty expected in achieving the goals of MTACCS.

3. MTACCS must be Limited in Complexity

It was pointed out in Chapter II that a common weakness of many defense programs is the desire to obtain the most sophisticated system available, regardless of cost and schedule delays.

Robert R. Everett[17] has written:

> There is a normal human tendency to want more than is provided. We have, in fact, enormously greater technical capability than we had a few years ago but we cannot do everything, certainly not for a reasonable sum of money... If some elements of the system are over specified, over complex, and over expensive, some other elements may have to go without and the performance of the whole system may be limited by the weaker parts... A considerable amount of thoughtful work is now going on into C^3 evaluation to help alleviate this problem, but it is one of great difficulty. [Ref. 40]

To avoid this pitfall, MTACCS should be limited in complexity. Here, limited is defined as attempting to develop a level of sophistication that is sufficient to achieve desired goals yet obtainable within time constraints at reasonable effort. Admittedly,

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[17] Robert R. Everett is a past president of the MITRE Corporation.

modifiers such as "sufficient" and "reasonable" are open to interpretation. The goal is not to establish rigid definitions, but rather to convey the idea that the problem must be approached in a practical manner, mindful of the time critical need for this system and of the fiscal austerity that looms in the future of MTACCS.

4. MTACCS must be Procured with an Effective Acquisition Strategy

The acquisition strategy determines the success or failure of a system. An effective strategy is one that provides an organized and consistent approach to meeting the program objectives within known constraints through an overall plan.

C. ASSESSMENT OF MTACCS COMPATIBILITY WITH CURRENT DOCTRINE

1. The Importance of Compatibility

The MTACCS Operational Concept Document states "the MTACCS concept supports and is consistent with service plans and doctrine" [Ref. 1]. There has, however, been no formal assessment found in the numerous MTACCS documents (many in draft) that addresses the subject of compatibility with current doctrine and established procedures. The compatibility factor can be a significant contributor to the downfall of any program. It was clear that the MIFASS program was crippled by its incompatibility with "accepted" doctrine and procedures. It was intended to operate within a doctrine of centralization that was characterized by the Fire and Air Support Center (FASC) concept. When decisions were made to remain primarily with decentralized procedures or use a combination of both, MIFASS was no longer entirely compatible. Major rework was

necessary to try and force MIFASS to support a doctrine, an organization, and a set of procedures that it was not initially intended to support. The MTACCS concept, its goals, and its objectives must be compatible with the ideas of warfighting as practiced in the Marine Corps today.

2. Warfighting Doctrine

a. Doctrine

Fleet Marine Force Manual 1, Warfighting, provides the authoritative basis for how Marines fight [Ref. 38:p i]. The manual establishes many of the guiding principles that Marines must use to achieve success in the conduct of war. Several key principles that are established by the manual will be discussed to provide a foundation in Marine Corps doctrine.

b. Maneuver Warfare

The Marine Corps concept for winning on the modern battlefield is a warfighting doctrine based on rapid, flexible, and opportunistic maneuver. It is through maneuver in both time and space, that a force can achieve decisive superiority at the necessary time and place. [Ref. 38:p 58] An emphasis on maneuver warfare implies a need for forces that are light, fast, and efficient

c. Decentralization of Command

The doctrinal issue of centralization versus decentralization was a pivotal factor on the failure of the MIFASS program. The support for decentralized control was stronger then and remains pervasive. FMFM 1 boldly asserts:

> First and foremost, *in order to generate the tempo of operations we desire and to best cope with the uncertainty, disorder, and fluidity of combat, command must be decentralized.* That is, subordinate commanders must make decisions on their own initiative, based on their understanding of their senior's intent... [Ref. 38:p 62]

d. Implicit Communications

Marine Corps doctrine promotes a reliance on the "human element" of command. Marine Corps philosophy must not only accommodate, but must exploit human traits such as boldness, initiative, personality, strength of will, and imagination. [Ref. 38:p 62] Along with this basic belief in the importance of the human element, the Marine Corps stresses the importance of "implicit communication".

> Implicit communication - to communicate through mutual understanding, using a minimum of key, well understood phrases or even anticipating each others thoughts - is a faster, more effective way to communicate than through the use of detailed, explicit instructions. [Ref. 38:p 63]

A practical implication of this philosophy is that Marines should communicate orally when possible, because we communicate in how we talk; in our inflections and our tone of voice. [Ref. 38:p 63]

e. Decision Making

The making of competent and timely decisions is recognized as essential to victory in war.

> Whoever can make and implement his decisions consistently faster gains a tremendous, often decisive advantage. Decision making thus becomes essential to generating tempo. We should spare no effort to accelerate that decision making capability. [Ref. 38:p 69]

f. Focus of Effort

More than 300 years ago, Antoine-Henri Jomini proposed the idea of a "decisive point" of vulnerability. Victory could be achieved only by massing one's forces against this decisive point. [Ref. 41] The idea of a "Focus of Effort" is a similar philosophy.

> Of all the efforts going on within our command, we recognize the focus of effort as being the most critical to success. All other efforts must support it. [Ref. 38:p 73]

An important implication of this principle is the need for coordination and integration of forces to maintain a focus.

g. Combined Arms

The Marine Corps has long advocated the integration of combined arms in the conduct of war.

> In order to maximize combat power, we must use all the available resources to best advantage. To do so, the Marine Corps must follow a doctrine of combined arms. Combined arms is the integration of arms in such a way, that in order to counteract one, the enemy must make himself more vulnerable to the other. [Ref. 38:p 75]

3. MTACCS Objectives that are Pertinent to Compatibility

Several important objectives of the MTACCS concept impact on its compatibility with current doctrine. The MTACCS operational concept document outlines the following general objectives that are pertinent to compatibility:

1. MTACCS must be as expeditionary as the force it supports.
2. MTACCS must permit commanders to lead from where they are most needed.

3. MTACCS should not impede mobility.

4. The communications architecture must evolve from a network of functionally dedicated voice channels into a system of digital information pipelines.

5. MTACCS will provide a common user, centrally managed database.

The first three of these listed objectives are entirely compatible with the doctrine that has been described. They demonstrate a recognition that the Marine Corps will operate in an expeditionary environment; an environment that mandates the capability to deploy rapidly and operate under austere conditions. The ideas of evolving communications and a centrally managed database, however, require investigation. Both imply the possibility of conflict with current doctrine.

4. Compatibility Assessment

a. An Evolving Communications Architecture

Historically, there has been considerable difficulty establishing what information should be data and what should remain voice in a C^2 system. [Ref. 30:p 228]. While current Marine Corps doctrine emphasizes voice transmissions, face-to-face interaction, and "implicit communications", the objective of MTACCS appears to be aimed at significantly reducing voice traffic. This conflict can have important implications. A conflict with doctrine can cause division within the Marine Corps and a loss of user advocacy.

The point is not trivial. In his book Command in War, Martin Van Creveld emphasizes the importance of informal communications:

> ... it is vital that the formal communication system be supplemented by an informal one that acts, so to speak, as lubricating oil. In any large organization, the virtues of formal communications systems - standardization, brevity, and precision - cannot be denied; those very virtues, however, also make such a system more subject to interruption and less flexible as a vehicle for original ideas... The danger that formal communications reduce command, and indeed thought itself, to trivia is a real one indeed. It must be guarded against by a design that deliberately leaves room for face-to-face, unstructured interaction... such exchanges represent the best way both of cutting down the total amount of communications that has to take place and of improving the quality of that communication. [Ref. 42:p 273]

b. A Centrally Managed Database

The centralization versus decentralization conflict was a contributor to the downfall of MIFASS. Since then, the Commandant has reemphasized the importance of the decentralization of command. A centrally managed database implies movement in a conflicting direction. It is true that a centrally managed database that is sufficiently replicated and distributed can support decentralized decision making. A complete assessment of this idea therefore, cannot be made. The particulars of the design and implementation of the centrally managed database have not yet been developed. The level and purpose of centralization continue to be an important concern in the future of MTACCS.

c. Conclusions on Compatibility

There continues to be considerable potential for doctrinal incompatibility within the MTACCS concept as currently stated. This compatibility problem can be averted but must be given appropriate attention in order to avoid a result similar to MIFASS.

The Field Development System concept document implies that doctrinal conflicts will be avoided since MTACCS will only affect how a task is performed and not by whom. This idea can help to avert the tendency towards centralization. If no changes are made in who makes the decisions, the system will tend to maintain a decentralized structure that reflects the current organization. Doctrine, however, also implies how something will be done, as has been shown. An emphasis on "implicit communications" implies voice transmissions, for example.

The centralization issue is especially sensitive. The degree of centralization must be explicitly defined and accepted early in the program. Robert R. Everett has written:

> The potential for centralization that resides in modern C^3 technology creates great tension in the military structure. The C^3 designer says "Let's provide the capability and argue about who does what later", but the local commander knows better. [Ref. 40]

D. ASSESSMENT OF MTACCS TECHNICAL FEASIBILITY

1. The Need to Work Within Technical Reality

Obviously, developers and contractors begin each new project with the belief that they can accomplish the task. They are optimistic. They have assessed the technical risks and judged them to be within reason. But this "judgement" is not infallible. It was shown in Chapter II that Norden Systems dramatically underestimated the volume and complexity of software necessary for MIFASS. This underestimation led them to believe they could build a system light enough to meet Marine Corps needs. When software requirements escalated, the hardware technology of the day was stretched beyond its

capacity. The hardware increased in size to handle the new processing requirements. Eventually, the sheer size and weight of the equipment became intolerable. It appears that processing fire and air support coordination in a box light enough and rugged enough for Marines was not possible given the technology limitations of that day.

Several technical risk issues have been identified by program coordinators and contractors. The possibility of problems in the areas of multi-level security and communications capacity have been anticipated. The possibility of continued software development problems was not specifically addressed in the documents currently available.

It is imperative that the MTACCS project assess the technical risk of implementing its goals. To that end, this chapter addresses three key technical questions that are derived from implied requirements:

1. Can current and projected communications systems meet the anticipated level of data communications?

2. Will adequate multi-level security be achievable?

3. What assurances are there that software development will succeed this time?

The ability to answer these questions is restricted for several reasons. Many of the requirements, for example, have not yet been defined. Valuable insight, however, can be developed from a qualitative calculation of the technical feasibility of meeting implied requirements.

2. Capacity of the Communications System

In October of 1988, the Naval Research Advisory Committee published a report on intra/interoperability of Marine Corps command and control systems. That report stated in its executive summary:

> ... it is unlikely that existing or planned tactical communications systems will have adequate capacity, connectivity, robustness, and multi-level security to support future battlefield information systems. [Ref. 43:p 3]

They found that the Marine Corps had not done an up-to-date analysis to define in detail the communications requirements to support the MTACCS component systems [Ref. 43:p 33]. It appears that there continues to be a lack of detailed information in this area. The draft MTACCS Master Acquisition Plan states: "No data has been developed to bound the communications requirement for MTACCS. The evolutionary developing MTACCS will be a source of feedback requirements for the communications system for the procurement of greater digital handling capacity." [Ref. 32:p 3]

The data requirements of MTACCS will, in all likelihood, quickly overwhelm the capacity of current communications systems. The Marine Corps expects this to happen. Specifics of the Marine Corps' plan to counter this problem are not entirely clear. One can speculate that the Corps is watching closely the progress of the Army in addressing this same problem. The Army's Tactical Command and Control System (ATCCS) will use some of the same tactical communications equipment that the Marine

Corps will use[18]. ATCCS will more than likely have similar data flow requirements. The army plan will include deployment of packet switch appliques to circuit switched bearer systems to extend their communications capacity. [Ref. 44:p 181]

An increase in the capacity of switching equipment alone, however, may not be sufficient. Much of the data traffic will continue to travel over single channel radio circuits, not a switched backbone. A switched backbone lacks the flexibility of single channel radio and it cannot completely supplant radio circuits.

3. Multi-level Security

The integration of the MTACCS component subsystems will require a capability for multi-level security. An operator utilizing the TCO system, for example, will have the capability of accessing several databases with varying levels of security classifications.

As noted earlier, however, there is little confidence in the evaluation community that the systems available or in development will have a secure, trusted, multi-level capability. With the leaps and bounds technology continues to make at an accelerated pace, the era of secure trusted systems is not far away. William Barker stated in Signal magazine that:

> All the necessary trusted computer and cryptographic components exist, what remains is the secure integration of the trusted cryptographic control functions into workstation hardware and evaluation of the resulting information security workstations. [Ref. 45:p 59]

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[18] Both the Army and the Marine Corps are fielding SINCGARS equipment, for example.

There is currently a commercial device in development that has demonstrated the ability to allow classified and unclassified users to share the same network without compromising classified information. This system works on the basis of encrypting the classified information, thereby rendering it unintelligible to unauthorized users. This means that many types and classifications of users can work on the same network without compromising classified information. This system, developed by Xerox, is reported to be able to turn any computer network into a network capable of handling classified data. [Ref. 46:p 92] Although this appears promising, the system throughput, after merging cryptographic functions with network level protocol functions, is still too slow for many user requirements and applications [Ref. 45:p 56].

There does not currently appear to be system capable of meeting the MTACCS requirements for information security if sensitive intelligence databases are to be an integrable part. The outlook is good for the future, but user confidence in secure, trusted systems must be cultivated in order for MTACCS to successfully integrate with the intelligence community.

4. Software Development

a. The Increasing Importance of Software

Software has become the dominant factor in many of today's military systems. This is especially true in command and control systems which tend to be very software intensive. An estimated 80-90% of the development costs of command and control systems can be attributed to software. [Ref. 47:p 92]

> In the 1960's, CIS managers went by a rule of thumb that put the cost of computer hardware at about seven or eight times the cost of software. Since that time, software costs have risen steadily...during this same period, hardware costs have come down rapidly...thus the ratio between the cost of hardware and the cost of software has shifted dramatically. Today, software costs are estimated to be about ten times greater than hardware costs. [Ref. 39:p 33-34]

Like most command and control systems, MTACCS will be software intensive. The development of MTACCS software will play a major role in determining the success of the program.

b. The Crisis in Software Development

While the capability of computer hardware has risen dramatically over the last decade, the capability of software has not kept pace. Major General Billy M. Thomas[19] was recently quoted in Army magazine as saying "the entire software industry is at the Model T Ford stage right now." [Ref. 48:p 36] Clearly, there is a low expectation of the current state of the software development art.

The excessive schedule delays and cost overruns in software development projects throughout the Department of Defense have reached crisis proportions. "Experts are now saying that the chief military software problem may soon be that DOD cannot get enough of it - period." [Ref. 49:p 27] This problem affects everybody. General James S. Cassity Jr.[20], USAF, wrote in 1988 ".. ask any program manager what

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[19] Major General Thomas was the Commanding General of the U.S. Army Communications-Electronics Command at the time of the Army magazine interview.

[20] Commander, Air Force Communications Command in 1988.

his or her number one nightmare is today and the answer is software; it is the cause of most program delays." [Ref. 50:p 39]

This crisis is not strictly a problem for the contractors to solve alone. Developers as well must take action to reduce the risk of software development failure. The report from a major software conference hosted by the Army's Communications Electronics Command (CECOM) in 1989 emphasized this point:

> Most of the current problems in software development are not technical in nature. They are management problems...unfortunately, little attention has been paid to the software development process, which is often poorly controlled. [Ref. 51:p 5]

In the development of MTACCS software, "management" is largely a responsibility of Marines; members of the three commands that together serve as the systems engineering management team. Marines must devote their fullest attention to the mitigation of software development problems.

c. *A History of Software Development Problems*

The MIFASS program was plagued with software problems, but MIFASS was not alone. Software problems are pervasive throughout the Department of Defense. General Bernard Randolph[21], USAF, was quoted in Military Forum as saying "on software schedules, we've got a perfect record; we haven't met one yet." [Ref. 49:p 29] Historically, software development in the military has been poor.

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21 Chief of Air Force Systems Command at the time.

d. How to Avoid the Software Development Dilemma

Avoiding the software dilemma is not easy. Experts in the field of software development are optimistic, but they also realize that major modification of the software development process is necessary. Many of these experts have recommended methods of improving the chances of successful development. Those recommendations are outlined here: [Ref. 51:p 8]

(1) Buy rather than build. Barry W. Boehm[22] has written:

> Clearly, if you want to improve your organization's software price-performance ratio, one major principle is "Don't build custom software where mass produced software will satisfy your needs." [Ref. 52:p 43]

(2) Build simpler products. It is an increasingly popular opinion that the only way to avoid excessive risk in the development of software is to settle for a modest software capability and see much of the capability of the hardware go unrealized. This opinion was colorfully presented in the SoftCon '89 report published by CECOM:

> We also need some appetite suppressants for the users. If you have to go to the hospital, it is better to have a Ford on the road than a Mercedes-Benz half built in the garage. [Ref. 51:p 5]
>
> The growing software shortage means that the end user will have to moderate his demand for unrealized performance which has so driven complexity, experts contend. It will also mean buying more off-the-shelf software available in the commercial market. Traditionally, the services have failed on both accounts. [Ref. 49:p 31]

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22 Barry W. Boehm was the chief scientist in the Office of Technology at the TRW Defense Systems Group when this article was published in 1987.

(3) Use prototypes. Valuable experience and insight to the users actual needs, and not perceived requirements, can be gained from the use of prototypes. A software prototype should be considered just that; a prototype. A tool to help identify requirements and to ascertain feasibility. The prototype demonstrates what technology is actually capable of and how the objective system should behave [Ref. 51:p 5]. The prototype provides the base for the operational solution, but rarely is the prototype sufficient in itself to be considered the best solution, both in operational capability and life cycle costs, to the operational requirement [Ref. 51:p 111].

(4) Involve the user in the requirements process. This is an idea that has been repeated continuously throughout this thesis and reference material as well. This is the only way to ensure that the system fielded is actually what the user wants and needs. The user does not have to be software literate in terms of design and engineering, but must be thoroughly proficient in his military occupation. Only by being thoroughly proficient can he ensure that the system will actually serve a useful role in the military environment.

Another idea that has been repeated also applies: the use of incremental development. Incremental development coupled with frequent, competent user feedback has proven to be the most effective technique for fielding useful systems. [Ref. 51:p 4]

(5) Plan for Controlled Technology Insertion. Most current software development problems are not technical, but are management related problems. Not

enough attention has been paid to the software development process. Rather, the concentration has been on exhaustive testing of a particular product. [Ref. 51:p 5] Coordinating the upgrading of software incorporating new technology should be planned in advance to ensure the effectiveness of the system as a whole is increased. It is possible to add new technology into a system which greatly enhances the performance of a particular part, but the overall performance of the system is degraded.

(6) Promote the use of standards. Standards improve our capability to communicate without hampering innovation. Standard interfaces and languages allow developers to concentrate on the program itself. Time and money is saved by not having to redevelop interfaces or work around software incompatibilities. [Ref. 51:p 104]

e. Current MTACCS Software Development Methodology

Pacific Northwest Laboratories has been contracted as the system engineer and integrator for MTACCS. Their draft recommendations for the software components of MTACCS were based on several general criteria:

1. Commonality. The recommended architecture should capitalize on developments made by the Army's CASS[23] working groups and by Marine Corps C^2 programs.
2. Interoperability. Recommendations should focus on enhancing communications between C^2 programs.
3. Non-Proprietary. No recommendation will be vendor specific.
4. Use of Non-Developmental-Items. No recommendations will rely on a product that has not been developed.

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[23] Common Army Tactical Command and Control System Support Software.

5. Availability/Maintainability. Recommended components should be easily available from a number of different sources and should be well supported and maintained,

6. Graceful Degradation. The overall architecture should provide sufficient redundancy so that loss of part of the system does not degrade the entire system.

7. Supportability of Future Developments. Recommendations should not prevent incorporation of new equipment or ideas into the system.

8. Recommendations should follow industry standards wherever possible. [Ref. 34:p 3.4]

f. Assessment of Software Development

It is clear that both the Marine Corps and its contractors are intent on implementing all of the generally accepted methods for averting disastrous problems in software development. Of the six recommendations listed earlier for avoiding software problems, Pacific Northwest Laboratories has specifically endorsed three as criteria for determining their software recommendations. The remaining three are expected to be implemented through the Field Development System (FDS). They are:

1. Build simpler products.

2. Use prototypes.

3. Involve the user in the requirements process.

These ideas, however, are still in their infancy. FDS-1 has not yet been demonstrated. Marine Corps' intentions for software development are promising, but a more detailed assessment will not be possible until the system matures.

5. Conclusions on Technical Feasibility

a. Capacity of the Communications System

There is a generally accepted expectation that the data requirements of MTACCS will exceed the capability of current equipment. Clearly, enhancements are required to boost the capability of the communications equipment. Developing these enhancements will take time, but there are at least several reasons for optimism:

1. The problem is already generally accepted.
2. The Army does have a plan to develop packet switch appliques to enhance communications capability.
3. MTACCS will be developed incrementally and is not expected to immediately overwhelm the communications system.

b. Multi-level Security

Although there is not a capability currently available, there has been a lot of promising progress in the commercial market place. At the rate of present development and market demand by the civilian sector, a multi-level security capability should be available within the next few phases of the MTACCS Field Development System.

c. Software Development

While software development continues to be an exceedingly difficult task throughout DOD, the initial outlook for MTACCS is favorable. MTACCS software development is still in its infancy, but the development procedures and criteria that have

been established are in complete agreement with software experts throughout both DOD and industry. If these procedures are maintained and adhered to, a successful software development project is likely.

E. LEVEL OF COMPLEXITY ASSESSMENT

It is explicitly stated in the MTACCS Operational Concept that:

> Systems and/or equipment complexity and operational sophistication shall be kept to a minimum consistent with providing the required operational capability to the MAGTF. [Ref. 1:p B-1]

While MTACCS is intrinsically complex, the current development approach does tend to limit the complexity of each FDS phase. A small, limited set of goals will be established for the first increment of MTACCS. Only those goals will be pursued. Greater sophistication will be left to follow on increments.

Throughout all of the FDS and MTACCS documents, there is a common theme: MTACCS must not and will not attempt to tackle too much in any one increment. There is caution expressed at every turn. The emphasis on the "build a little, test a little, field a little" approach is a reassuring indication that the project will proceed with complexity held within practical limits.

F. ASSESSMENT OF ACQUISITION STRATEGY

1. The Impact of Acquisition Strategy

Poor acquisition strategy decisions can have serious adverse effects on any program. In retrospect, it was a poor strategy of the MIFASS program, for example, to

choose hardware configurations first, then work on software. The negative effects of this strategy were pointed out in Chapter II. The use of an appropriate acquisition strategy is vital to the success of the program.

2. Acquisition Strategy Defined

Acquisition strategy is defined in the Defense Systems Management College Acquisition Strategy Guide as:

> A conceptual basis of the overall plan to follow in program execution. The acquisition strategy is the basis for all functional strategies, plans, and tasking; it provides a coordinated approach to achieving program objectives within the constraints placed on the program. [Ref. 53:p 3-21]

The main ingredients for successful acquisition of systems involves strategic, technical, and resource concerns. Program objectives must be established, controlled, and assessed to permit the deployment of a militarily useful system that meets cost, schedule, performance, and supportability goals.

The acquisition strategy must show how the system and program objectives will be met, how policy and procedures will be accommodated, and how the conduct of the program will meet such criteria as realism, stability, resource balance, flexibility, and controlled risk. [Ref. 53:p 3-21]

The benefits of a sound acquisition strategy allow the program manager to maintain control and provide direction to his management effort. Some of the realized benefits are:

1. Providing a consistent and organized approach.

2. Providing a coordinated approach to achieving program objectives economically and effectively through informed and timely decisions.

3. Providing a baseline for preparing plans and activities to facilitate program understanding and agreement.

4. Documenting decisions and assumptions made in the process of acquisition.

5. Providing important political credibility. [Ref. 53:p 3-2]

These are more than just benefits, they are crucial to a systems success. Without them, political support, and hence financial support, is difficult to maintain.

The acquisition strategy should be determined as early in the systems life cycle as possible. The impact of decisions made early in the cycle substantially determine the majority of the costs later in the cycle.

[Ref. 53:p 3-2]

3. The MTACCS Acquisition Strategy

a. Evolutionary Acquisition

The MTACCS acquisition concept is a "build a little, test a little, field a little" approach using off-the-shelf equipment and software where applicable. It is a strategy known as "Evolutionary Acquisition". Evolutionary Acquisition is defined as:

> An acquisition strategy which may be used to procure a system expected to evolve during development within an approved architectural framework to achieve an overall systems capability. An underlying factor in Evolutionary Acquisition is the need to field a well defined core capability quickly in response to a validated requirement, while planning through an incremental upgrade program to eventually enhance the system to provide the overall system capability. These increments are treated as individual acquisitions, with their scope and context being the result of both continuous feedback from developing and independent testing agencies and the user... [Ref. 54:p 23]

Requirements are to originate from the Fleet Marine Force to ensure users needs are met. System development must be managed from the Program Executive Officer (PEO) to ensure an integrated C^2 system. User requirements will be satisfied in a coordinated, evolutionary manner using non-developmental automation and secure/reliable digital communications equipment. [Ref. 1:p 7]

The MTACCS Operational Concept Document establishes the following policies:

1. Marine Corps requirements for new acquisition shall be satisfied, whenever suitable and acceptable, through the programs of other services, government agencies, or joint developmental efforts.

2. When existing, proven technology will satisfy a requirement, it shall be used. Standard Marine Corps equipment and other off-the-shelf components shall be used unless specific justification to do otherwise is provided. [Ref. 1: Appendix B]

Again, these policies imply the maximum use of Non-Developmental Items (NDI) and Commercial Off-The-Shelf (COTS) material.

Evolutionary acquisition is an alternative acquisition process used to acquire command and control systems that are <u>expected to evolve</u> during development and throughout their operational life.

Figure 22 graphically represents the application of an evolutionary acquisition approach. The figure emphasizes that the initial preliminary system architecture is segregated into planned increments. Those increments are then refined, funded, and developed in stages. [Ref. 55]

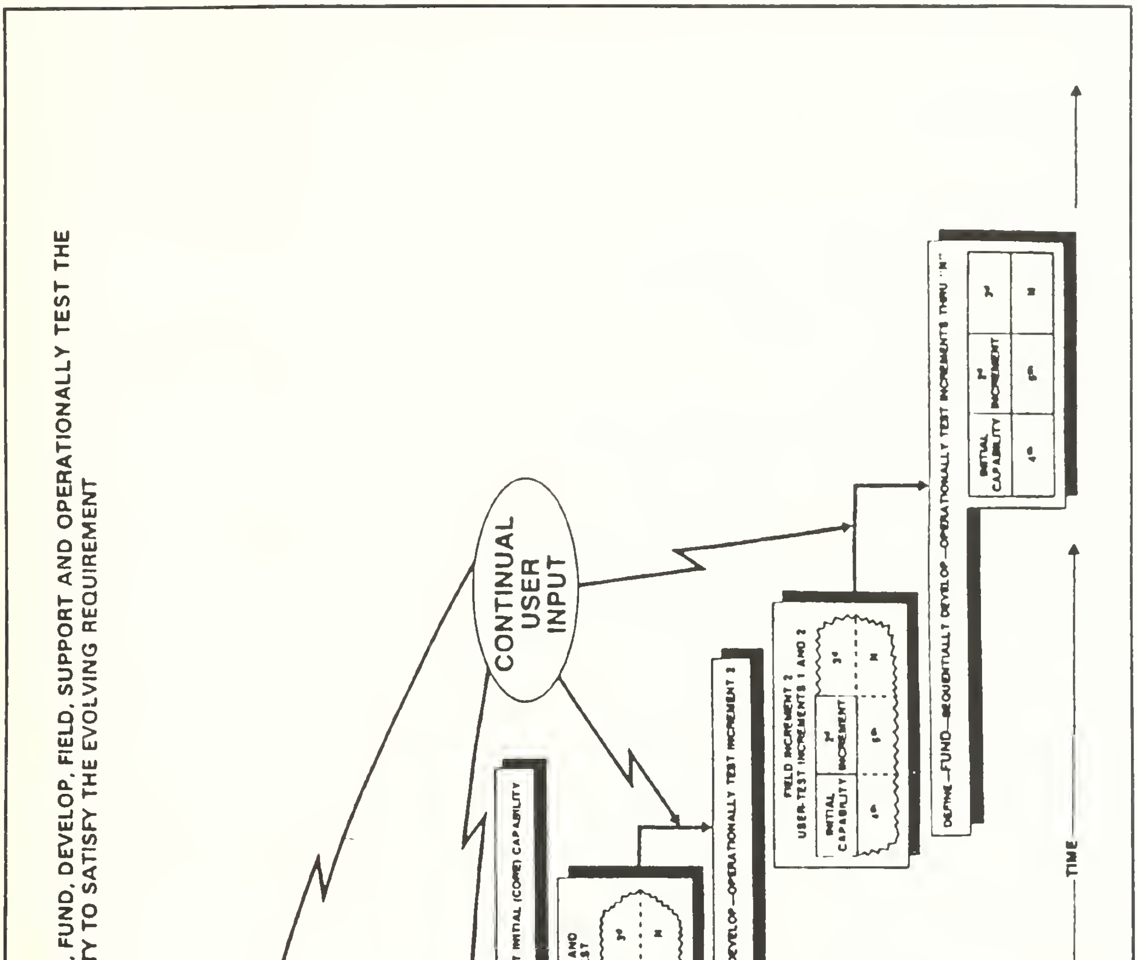

Figure 22: A Model of Evolutionary Acquisition [Source: Ref. 55]

b. Motivation for Employing Evolutionary Acquisition

The Marine Corps has chosen to develop MTACCS through the use of Evolutionary Acquisition for several reasons:

(1) Lessons Learned From MIFASS. As discussed in Chapter II, the Marine Corps' attempt at the "big system approach" has failed miserably in the past at extreme cost. It was simply too hard to adjust requirements and specifications to keep up with both user demand and technology, and quickly incorporate these adjustments into a system. [Ref. 32:p 16] Using Evolutionary Acquisition, improvements or changes can be made at the next incremental upgrade and can be made easily if the original core design was built with changes in mind.

(2) Lack of a Firm, Complete List of Defined Requirements. A complete list of C^2 automation or support requirements would be impossible to generate. The introduction of new technology and procedures makes old tasks easier and opens the door to provide new capabilities. This makes it difficult to predict the final requirements. [Ref. 32:p 16] By using Evolutionary Acquisition, the user can provide timely, accurate feedback of what he wants, needs, and actually uses. This feedback can be applied to the next increment and tested.

(3) Growing Political Acceptance of Evolutionary Acquisition. The use of Evolutionary Acquisition as an alternative acquisition strategy is consistent with the guidance of OMB Circular A-109, DoD Directive 5000.1, and with Defense Acquisition Circular 76-43. Evolutionary Acquisition encourages regular and continual interaction

with Deputy Program Managers (DPM)[24], requirements proponents, users, developers, testers, and logisticians. It encourages the consideration of Non-Developmental-Items (NDI) and Commercial-Off-the-Shelf (COTS) materiel where applicable. [Ref. 32:p 16] By this continual interaction, the risk of spending a large amount of resources with no measurable return is reduced. The program is reviewed by all concerned at each increment. Those responsible for certain fields will have to interact repeatedly with those responsible for the other fields that could effect them.

(4) The Ability to Impact and Coordinate Subordinate Programs. Since several of the MTACCS component systems are being developed by separate DPMs under the PM, MAGTF C^2, each DPM will be given the same set of standards, interface criteria, and requirements to incorporate into their systems. The DPMs will manage the development of their separate systems, but with a common goal to be achieved. Their progress will be reviewed for compatibility by the same senior; one person, not a revolving committee. [Ref. 32:p 17] This will help to ensure that MTACCS subsystems are interoperable and the Marine Corps will not suffer drastic logistical burdens supporting a multitude of completely different systems.

(5) The User Response is Quickly Incorporated. By starting with equipment and procedures the user is already familiar with, and incorporating a limited amount of change at each increment, the user can easily assimilate and evaluate the

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[24] Deputy Program Managers are responsible for subsystems under the MTACCS engineering effort. They report to the PM, MAGTF C^2.

change, providing appropriate and accurate feedback. Through the use of FDS, this is possible.

(6) Capabilities are Fielded Faster. Evolutionary Acquisition permits faster fielding of core capabilities to the user. It allows building on existing equipment and systems to quickly field a useful core capability and concurrently develop component systems, capitalizing on the ability to incorporate component systems as they complete their individual development phases. [Ref. 32:p 16] This permits new technology to reach the user at a rate that is much faster than currently possible.

4. Assessment of the Feasibility of the Evolutionary Acquisition Strategy

a. Emergence of Evolutionary Acquisition

Evolutionary Acquisition is gaining recognition as a strategy that provides the flexibility necessary to adapt evolving command and control systems. Robert R. Everett has written:

> I believe that to resort to evolution is not a failure of the overall design process, but recognition that evolution is the way that complex systems actually do change. [Ref. 40]

In 1987, the Joint Logistics Commanders[25] endorsed a guide for evolutionary acquisition. The guide was prepared by the Defense Systems Management College. The guide noted:

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[25] The Joint Logistics Commanders are the Commander, U.S. Army Materiel Command, the Deputy Chief of Naval Operations (Logistics), the Commander, Air Force Logistics Command, and the Commander, Air Force Systems Command.

Significant studies have been conducted in the field of evolutionary acquisition by authoritative, learned and experiences groups representative of public and private sectors of our economy. These studies have concluded that for the acquisition of C^2 systems an evolutionary approach should normally be used. [Ref. 55]

Brigadier General Edward Hirsch[26], USA (Ret), wrote in an article in Signal magazine:

> Evolutionary Acquisition is not a cure-all for the real or perceived ills of the U.S. acquisition process; but it does hold some promise to help field command and control systems sooner, at lower cost and with higher user satisfaction than other approaches. [Ref. 54:p 23]

b. Non-Developmental Items and Commercial-Off-The-Shelf Products

Non-Developmental Items and Commercial-Off-the-Shelf products are generic terms that describe material available from a variety of sources with little or no development by the government. These are items that are either available in the commercial market place or from other services.

According to William H. Taft IV[27], 'The use of Off-The-Shelf sources is a major initiative of the Department of Defense [Ref. 56:p 103]. There is considerable motivation for the Marine Corps to pursue this element of acquisition strategy wherever possible. Non-Developmental Items yield several benefits:

1. The time in development and the time to fielding is greatly reduced.
2. Users requirements and needs can be met and satisfied quickly.

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[26] Director, Center for Acquisition Management Policy, Defense Systems Management College at the time of publication of the article.

[27] Former Deputy Secretary of Defense.

3. Costs for Research and Development are reduced.

4. Current, state of the art technology is used and fielded. [Ref. 57]

However, there are risks involved with using Non-developmental Items. These include:

1. Cost and performance tradeoffs to accommodate the use of NDI components in production.

2. The resulting proliferation of hardware and software can cause logistic support, training, and configuration management problems and possible increased life cycle costs.

3. Safety deficiencies may occur because the NDI was not built specifically for a military environment. [Ref. 57]

The benefits of using NDI should aid in the fielding of MTACCS tremendously. The risks are being minimized through the use of the common hardware and common software. By restricting the amount and type of each, many of the logistical and training burdens are alleviated.

c. *Conclusions on Acquisition Strategy*

The Evolutionary Acquisition strategy is widely accepted as an appropriate method for developing complex, integrated systems. William E. Leigh and Clifford Burgess[28] assert in their book Distributed Intelligence:

> Building complex, integrated systems in a single project seldom is successful and rarely is attempted. Normally, integrated systems are the result of an evolutionary

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[28] Associate Professors, University of Southern Mississippi when they published their book in 1987.

sequence of development, modification, and enhancements of multiple systems originally designed to operate in a stand alone fashion. [Ref. 39:p 50]

... attempting to solve a problem or set of problems that is too large in scope virtually guarantees that the solution will be obsolete by the time it is developed fully. [Ref. 39:p 56]

... options that can be implemented as modules that are relatively narrow in scope are becoming increasingly attractive. [Ref. 39:p 56]

The use of this strategy in the development and procurement of MTACCS dramatically increases the probability of success, but it is still not tested on a project of such complexity.

G. CONCLUSIONS ON FEASIBILITY

The MTACCS concept is feasible. The use of an Evolutionary Acquisition strategy markedly strengthens the program. In an evolutionary , incremental development, advances in technology can be more readily introduced as upgrades to the core system. There are several factors, however, that can undermine the basic feasibility of the project. These factors must be addressed and mitigated to ensure they do not inhibit development.

1. Use of Data Communications

The MTACCS program must ensure that informal communications and voice radio are not entirely supplanted by data communications. To rely too heavily on data transmissions violates the spirit of Marine Corps doctrine and runs the risk, as Van Creveld said, of "reducing command to trivia" [Ref. 41:p 273].

2. Centralization

A clear vision of the degree of centralization of command and control must be established early and maintained. In addition, it is vital that the degree of centralization be strongly supported across the entire Marine Corps. There must be consensus. Division on this highly critical issue can cripple the program.

3. Communications Capacity

The simultaneous development of both MTACCS and its supporting communications system is a hauntingly familiar scenario. The MIFASS system was also intended to operate with communications equipment that was being developed concurrently. When the communications equipment experienced delays, MIFASS was handicapped. It did not have a communications system capable of providing adequate support. The Marine Corps must be very concerned that this does not occur again with the "revitalized" MTACCS. The Naval Research Advisory Committee has cast doubts on the ability of both current <u>and future</u> communications equipment to handle the load. Action must be taken to plan for that contingency.

4. Multi-level Security

Continued emphasis must be placed on establishing multi-level security if TCO is to interface with IAS and provide unit commanders with real time intelligence. Without a demonstrated secure, trusted system, there will be little user support for allowing classified information of a sensitive nature to be passed on MTACCS nets. There is a need to allow users of differing security levels to be able to access the same

system using the same database. Until this can be done with a high degree of confidence, our intelligence system could be unintentionally violated. Fortunately, there appears to be a strong interest displayed, by both industry and the services, in the development of multi-level security for both military and commercial applications. It appears that the Marine Corps need only follow those developments closely and evaluate candidate methods to determine the method most appropriate for Marine Corps needs.

5. Software Development

Software development continues to be DOD's "Achilles' heel". The MTACCS development team has laid out a development plan that incorporates the best advice of the time. However, the plan must be adhered to. The software must be adequately tested and progress demonstrated to avoid making decisions based on promises and reputations as MIFASS did. The acquisition strategy must be able to react to new technologies, processes, and strategies.

V. COST-EFFECTIVENESS ASSESSMENT

A. INTRODUCTION

1. Purpose of this Chapter

The purpose of this chapter is to examine the combat effectiveness of MTACCS in relation to its cost. Automation of a particular task or set of procedures is generally thought to improve combat effectiveness. While MTACCS may indeed improve the efficiency with which assets are used and increase the overall effectiveness of the Marine Corps, is it the most cost effective method? Could the same level of effectiveness be achieved at a lower expenditure of resources if something else was purchased? These questions will be addressed here.

2. The Importance of a Cost-Effectiveness Assessment

The procurement of a C^2 system as extensive as MTACCS is an expensive proposition. Hundreds of millions of dollars were spent on the failed MIFASS system alone. Given this significant investment, several vitally important issues must be addressed:

1. Is it worth the expense?
2. Will it significantly enhance combat effectiveness?
3. Would the Marine Corps be better off to buy more weapons and less C^2?
4. What is the most cost-effective level of automation?

These are difficult questions to answer. The information presented here provides insight to possible answers, but does not address the level of detail necessary to determine the best answers.

3. Assessment Methodology

Questions of this nature are generally answered by cost-effectiveness studies. A complete cost-effectiveness study of MTACCS as it currently stands, is beyond the scope of this thesis. Fortunately, several cost-effectiveness studies have been completed. Two of these studies will serve as a foundation for an assessment of the potential of the "revitalized" MTACCS to enhance combat effectiveness. Both were conducted in 1981 by the Center for Naval Analyses (CNA). The first is a study of the Tactical Combat Operations (TCO) system as it stood then. The second addresses the Marine Air Ground Intelligence System (MAGIS).

Cost-effectiveness may be assessed in two parts: combat effectiveness and cost-effectiveness. First, the combat effectiveness section will examine the change in combat capability that MTACCS may provide. The cost-effectiveness section then relates the amount of change in combat effectiveness that can be attributed to MTACCS to the resource cost of the system.

This chapter will use TCO as its primary example due to the role TCO will maintain as the system integrator for MTACCS. It is, in essence, the hub of MTACCS. TCO possesses the functions and tools with which to allocate forces and assets, while processing intelligence, and disseminating orders and plans. TCO is the primary component of the initial MTACCS development. It is geared towards providing

automated assistance for MAGTF command and control through the integration of the MTACCS component systems. An assessment of TCO will closely approximate an assessment of the integrated MTACCS system.

Additionally, a second CNA study that addresses the Marine Air Ground Intelligence System (MAGIS) Intelligence Analysis Center (IAC) is reviewed. The IAC study has two drawbacks, however. First, only measures of performance were tabulated. Measures of force effectiveness were not considered. Second, a cost-effectiveness trade-off between the manual system and the IAC was not developed.

4. Limitations of the Assessment

The CNA studies were completed ten years ago, well before the "revitalization" of MTACCS. This places limits on the validity of an assessment of the "new" MTACCS. Extensive similarities remain, however, and much of the analysis of the earlier version of these can be applied today. The cost-effectiveness studies are used to illustrate the potential benefits and limitations of an automated C^2 system.

B. THE IMPACT OF MTACCS ON COMBAT EFFECTIVENESS

An evaluation of combat effectiveness usually requires extensive modeling and simulation. Modeling and simulation, however, are outside the scope of this assessment. The impact of MTACCS on combat effectiveness will be concluded from prior studies.

1. The Center for Naval Analyses TCO Assessment

a. Background

The basic approach used in the TCO analysis was a three tiered approach. Each alternative was evaluated on a first level using measures of performance (MOP's), on a second level using measures of effectiveness (MOE's), and on a third level using measures of force effectiveness (MOFE's). The study concluded with the evaluation of the effectiveness of equal-cost alternatives. [Ref. 58:p 1] Five relevant alternatives were analyzed, four variations of TCO[29] and a manual system:

1. Full TCO - TCO as described in Chapter III with fully functioning nodes down to the battalion/squadron level.

2. Nodally Austere TCO - The nodes at the battalion/squadron level were eliminated.

3. Functionally Austere TCO - Decision aids were eliminated at all levels.

4. Very Austere TCO - The nodes at the battalion/squadron level were eliminated and the decision aids at all levels were eliminated.

5. Manual System - The majority of information was maintained on status boards, overlays, and paper files.

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[29] The CNA analysis evaluated TCO with the MIFASS concept before the revitalization of MTACCS in 1989. Since the majority of the MTACCS subsystems were in the development phase, only the concepts and not the systems themselves were being analyzed. The concept for TCO has remained essentially the same in many respects.

b. Evaluation Criteria

(1) Measures of Performance

(a) Timeliness. Timeliness represents the time that elapses between the first occurrence of an event and when information concerning that event is processed and translated into action.

(b) Accuracy. Accuracy is the degree of correctness of the information in the system. Each system can only be as accurate as the information put into it. [Ref. 58:p 7] It is assumed that the same caliber of input is used in each case, and the measurement of accuracy is in the transmission of the data.[30]

(c) Decision Aids. The change in effectiveness due to decision aids was measured through the use of three decision aids: Battlefield Simulation, Air Routing, and Air Weaponeering. Battlefield Simulation is basically a war game with which to test and improve operational plans before implementation. Air Routing allows the pilot to choose the optimal route with an Electronics Counter Measures (ECM) plan to ensure survival and mission effectiveness. Air Weaponeering aids in matching targets with optimal weapons.[31] [Ref. 58:p 6]

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[30] In a manual system, information can be significantly delayed resulting in erroneous perceptions. These delays are usually due to voice transmission taking too long to convey information and having to wait for a turn on the net. In an automated system, messages generally travel faster with greater accuracy.

[31] The current TCO system has not yet identified the decision aids to be included.

(2) Measures of Effectiveness

(a) Perceptions. The commander's estimate of enemy strength was used as an indication of his perception of the battlefield. [Ref. 58:p 6]

(b) Resource Allocation. The allocation of rifle squads between front line battalions and the reserves was used as an indication of resource allocation. The more accurate the commander's perception of the battlefield, the more accurately he can allocate his forces. [Ref. 58:p 6]

(3) Measure of Force Effectiveness. The loss ratio was used as a measure of force effectiveness. The loss ratio was defined as the ratio of enemy losses to friendly losses after two days of simulated battle. [Ref. 58:p 6]

c. Effectiveness Results

(1) Time Delay (Figure 23). There is a readily observable difference between the automated systems and the manual system. This was attributed to increased processing speed and transmission speed. The human processing at the receiver is considered the same for each system. It became apparent that decision aids are not a factor in the speed of the decision based on these results. [Ref. 58:p 4]

(2) Error Rates (Figure 23). Again, there appears to be a significant difference between automated and manual systems. Automated systems demonstrate half the error rate of the manual system.

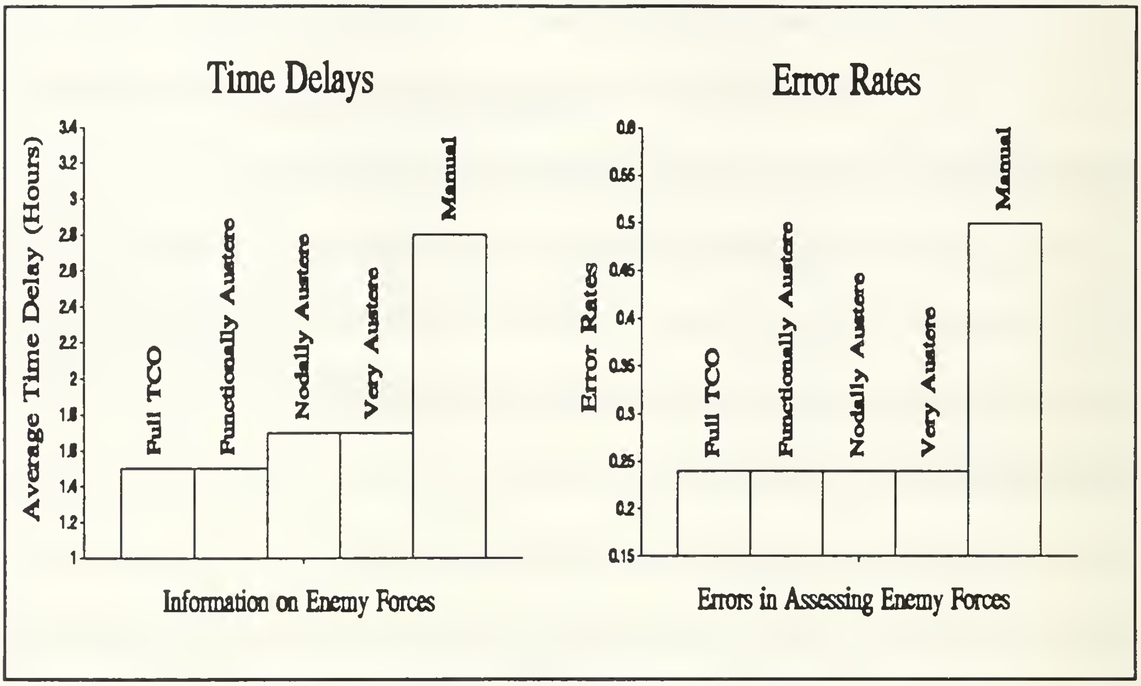

Figure 23: Error Rates and Time Delay [Source: Ref. 58]

(3) Decision Aids. In the analysis, Battlefield Simulation yielded a 26% decrease in the rate of friendly casualties. Air Routing produced a 30% reduction in aircraft vulnerability. Air Weaponeering increased the effectiveness of delivered ordnance by 76%. [Ref. 58:p 5] Clearly, decision aids can contribute greatly to the combat effectiveness of a force.

(4) Perceptions (Figure 24). The study also analyzed how the improvements in a C^2 system can impact the commander's perception of the battlefield. The starting premise was:

> The current perception is a function of the previous perception and the "new" information that is becoming available. Due to time delays in the system, the "new" information may be hours old. These two factors are weighted so that the higher the confidence in the "new" information, the more reliance on it. [Ref. 58:p 6]

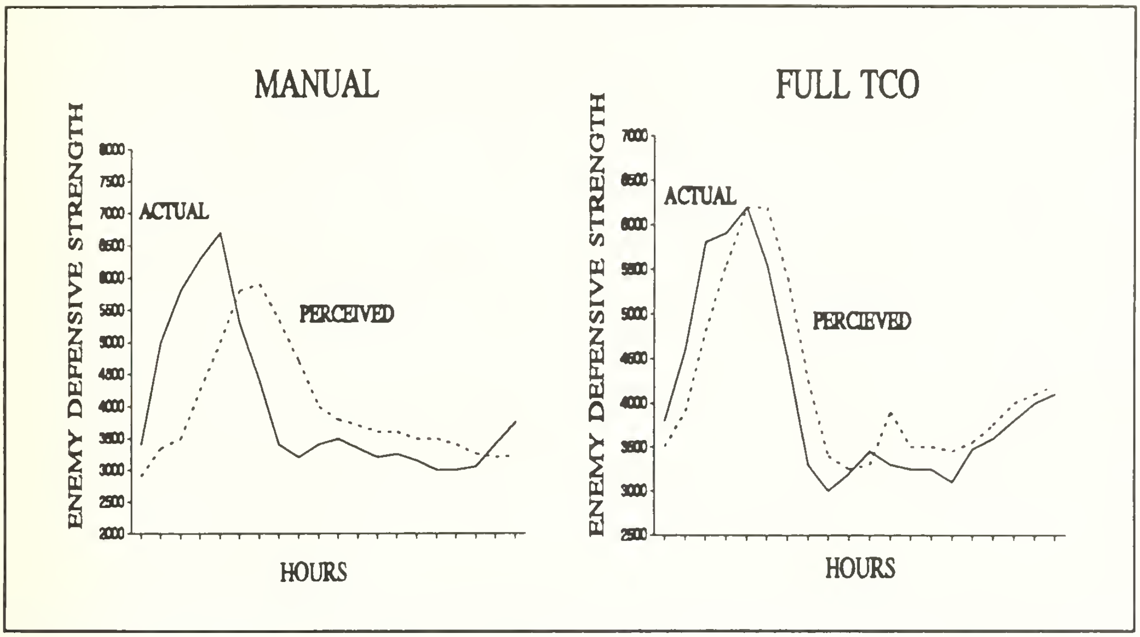

Figure 24: Perceptions of Enemy Strength in the TCO assessment [Source: Ref. 58]

It became obvious from the results and from military experience, that perceptions will tend to lag behind the actions and intentions of the enemy. Figure 24 depicts this time lag of friendly perceptions and enemy actions. The analysis demonstrated that the automated system had roughly a one hour time lag while the manual system averaged a four hour time lag. There was also a noticeable difference in the accuracy of the commander's perception. Accuracy in enemy strength showed an average error of 1300 soldiers for the manual system. The average error was only 350 soldiers for the automated system. Overall, the automated system resulted in a much more accurate perception of the battlefield.

(5) *Resource Allocation.* Resources were allocated based on perceptions. Figure 25 shows the movements of rifle squads between the front lines and the reserves. The allocation of rifle squads was based on a fixed decision rule which was a function of the current battlefield perceptions. Therefore, the more accurate the perception of enemy forces and intent, the more appropriate and effective the allocation. The manual system, due to its inaccuracies in perception, assigned rifle squads in a poor fashion as compared to the more accurate TCO system. [Ref. 58:p 6]

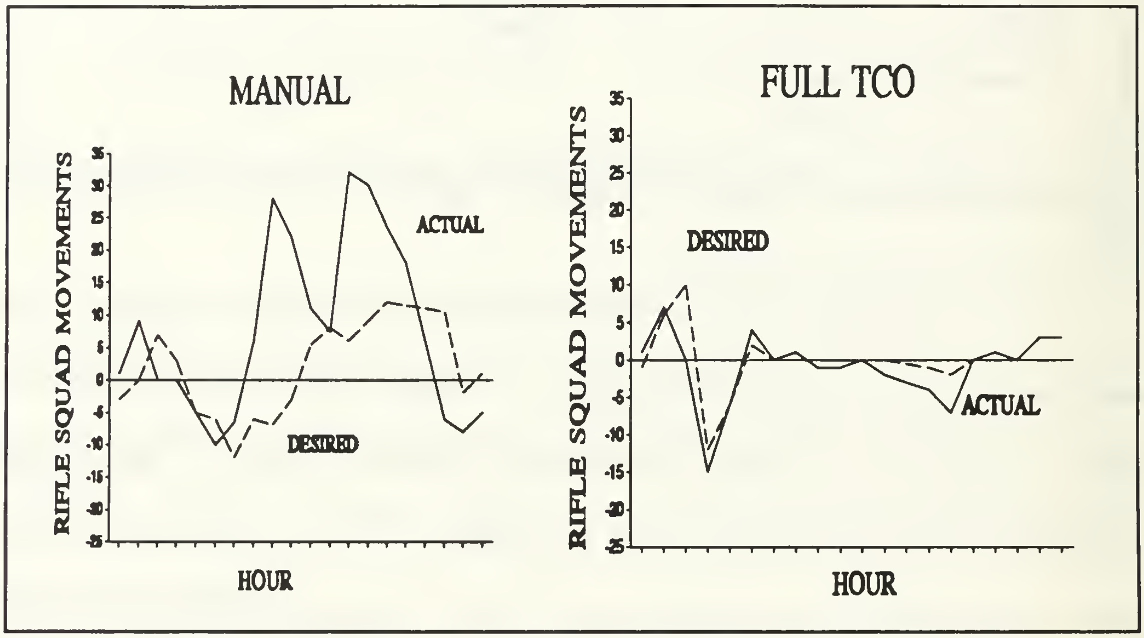

Figure 25: Resource Allocation in the TCO assessment [Source: Ref. 58]

(6) *Loss Ratio.* In the analysis[32], battle outcome was determined by the final loss ratio. The results were all normalized and portrayed relative to friendly losses. Command and control was incorporated by keeping track of the two views of the

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[32] The analysis used a deterministic, two sided computer model know as the C^2 Model. The model portrays a large scale amphibious assault of a Marine Expeditionary Force.

battlefield; the commander's perception and the actual situation. Plans, resource allocation, and control of the battle were conducted based on the commander's perceptions. The outcomes of the commander's decisions, of course, were based on the actual situation. Table I shows the resulting final loss ratios. [Ref. 58:p 8] The ratios can be roughly segregated into three levels of effectiveness. The Full TCO and Nodally Austere TCO achieved a similar level of effectiveness, performing significantly better than all of the other systems. The Functionally Austere TCO and Very Austere TCO both performed at a similar level of effectiveness that was significantly lower than the other two automated alternatives. The overriding difference between these two and the other automated systems is in the use of decision aids. The values shown in Table I illustrate the relatively higher value of decision aids compared to that of having additional automation at lower echelons. Again, this implies that decision aids can significantly impact the outcome of the battle.

2. The Center for Naval Analyses MAGIS Assessment

a. Background

The CNA analysis focused on a cost and operational analysis assessment of the MAGIS Intelligence Analysis Center (IAC). Three automated alternatives to the IAC were considered, but none were found to be suitable. These were the existing intelligence systems of the Army, Navy, and the Air Force. The study, then, compared

Table I: LOSS RATIOS IN THE TCO ASSESSMENT [Source: Ref. 58]

ALTERNATIVE	RELATIVE LOSS RATIO
FULL TCO	1.14
NODALLY AUSTRER TCO	1.11
FUNCTIONALLY AUSTERE TCO	1.04
VERY AUSTERE TCO	1.03
MANUAL	1.00

only two alternatives: the IAC and a manual system. The effectiveness data came from two sources. The 1975 operability test of the Intelligence Analysis Storage and Retrieval System was the source for manual data. The 1979 Developmental Test II of the IAC provided data for the automated alternative. [Ref. 46:p v]

b. Methodology

In the previous TCO analysis, a three tiered approach was used. The TCO system was evaluated against measures of performance (MOP), measures of effectiveness (MOE), and lastly, measures of force effectiveness (MOFE's). In the IAC analysis, only performance was measured. [Ref. 59]

c. *Measures of Performance*

The measures of performance used during the IAC analysis are defined here.

(1) Percentage of Required Products Produced. The number of required products that are actually produced by the test team divided by the total number required. [Ref. 59:p 33]

(2) Completeness. The percentage of items that are complete, based on those outputs that are actually produced. The percentage is obtained by comparing the items completed by the test team with the predetermined solution. [Ref. 59:p 33]

(3) Accuracy. The percentage of those items completed that are correct, based on the predetermined solutions. [Ref. 59:p 33]

(4) Timeliness. The deviation between the actual output time and the scheduled output time. A negative timeliness score indicates that the output was produced earlier than required. [Ref. 59:p 34]

d. *Summary of Effectiveness Results in the IAC Analysis*

The CNA study concluded that the IAC was a significant improvement over the manual system. Test results showed that the IAC provided a marked measure of improvement in the first three of the performance measures. The measure of timeliness, however, greatly favored the manual system. For this reason, the analysts expressed concern that the results of the two tests were not entirely comparable in the timeliness measure. Some limitations were developed as a result of these conclusions.

e. *Limitations of the CNA MAGIS Assessment*

(1) MOP's versus MOFE's. Measures of performance (MOP's) are an indicator of the isolated performance of the system only. MOP's do not provide an accurate indication of the overall impact on combat effectiveness. [Ref. 59]

(2) Two Tests not Entirely Compatible. As mentioned earlier, the results of the two tests were compiled to produce the MAGIS IAC assessment. These tests were not administered under the same, or in some cases, even similar conditions. CNA analysts were required to manipulate the test data to achieve a rough comparability between the tests. [Ref. 59]

(3) Production of Required Reports. In the manual method, production of required reports could begin at any time. Intelligence personnel were able to start reports well before the required delivery time based on information available at the time. Users of the automated system were not permitted to begin report preparation until a certain time prior to the required delivery time. [Ref. 59]

f. *Conclusions on the Effectiveness of the IAC*

The CNA analysis revealed that automation of the intelligence system has the potential to substantially improve system performance. The analysis has limited utility, however, because it did not address the potential of the automated system to improve force effectiveness.

C. COST-EFFECTIVENESS

1. Definition

Cost-effectiveness studies generally attempt to evaluate the effectiveness of various alternatives on a common scale, then relate the effectiveness "score" for that system to its cost. A system is most cost-effective when it provides a larger incremental increase in effectiveness per unit of cost.

2. The TCO Cost-Effectiveness Assessment

a. Background

The TCO study performed an equal cost analysis with the five systems described earlier. The most expensive system, full TCO, was used as a cost baseline. The difference in cost between the Full TCO alternative and the other systems was used to purchase more firepower. Additional tanks were added to the less expensive alternatives. Figure 26 shows the breakdown of the estimated costs of the C^3 systems plus the number of tanks added to achieve equal cost forces. Using the C^2 model described earlier, the equal cost forces were evaluated and the final loss ratios tabulated. [Ref. 58:p 10]

b. Cost-effectiveness Results

The cost-effectiveness results in Table II show that automation of command and control is an effective method of increasing combat effectiveness. It is important to point out, however, that the Full TCO was not the best performer. The Nodally Austere TCO system did achieve a higher score in loss ratio. Although the

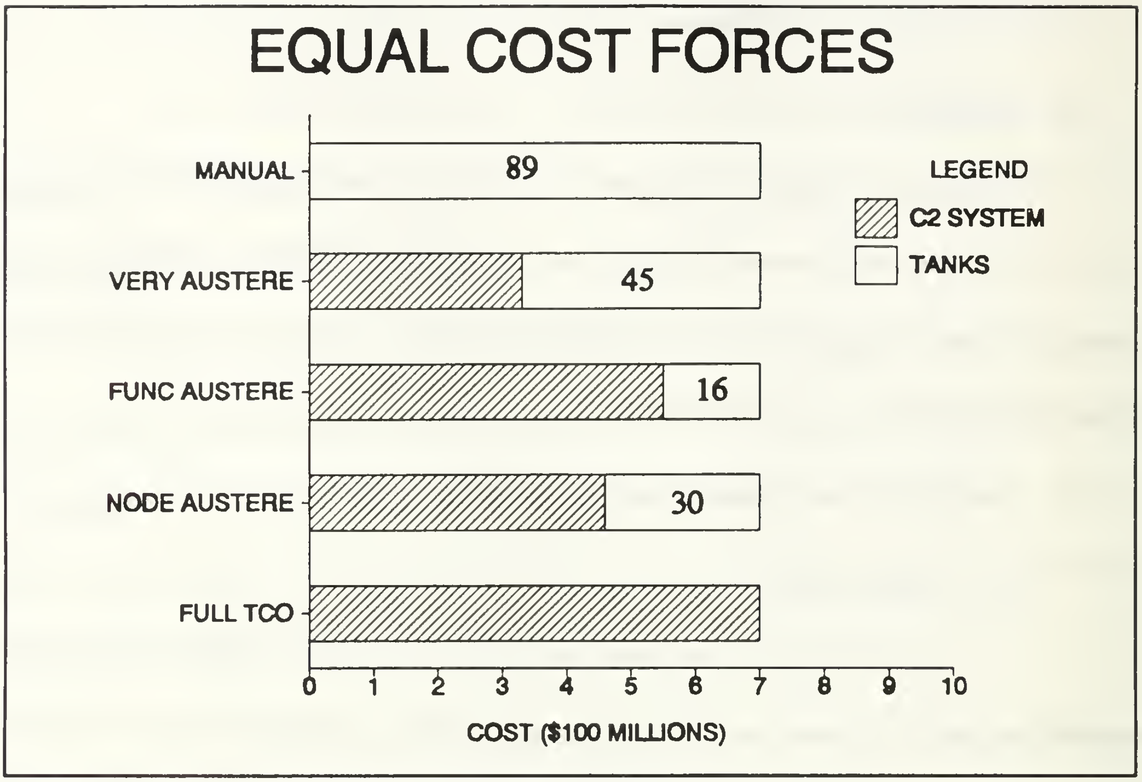

Figure 26: Equal Cost Forces [Source: Ref. 58]

difference may not be statistically significant, the implication is clear. Given the ability to buy firepower, or C^2, or a combination of both, choosing a proper combination may be the most appropriate decision.

c. Limitations of the TCO Study

The results of the TCO study must be tempered with the facts that:

1. Only tanks were used as additional sources of firepower. If the money had been spent on helicopters, artillery, or additional forces the outcome of the simulation could have been different.

2. It was a specific scenario against a specific enemy.

3. Only one type of computer model was used.

Table II: EQUAL COST LOSS RATIOS [Source: Ref. 58]

ALTERNATIVE	LOSS RATIO
NODALLY AUSTERE	1.14
TCO	1.13
VERY AUSTERE TCO	1.03
FUNCTIONALLY AUSTERE TCO	1.01
MANUAL	1.00

4. The computer model is only a representation of reality; a representation of unknown fidelity.

d. *Summary*

The Center for Naval Analyses study of the TCO system showed that the automation of command and control tasks can greatly increase combat effectiveness. It is also important to note from the results, that automation of C^2 below the regimental level did little to enhance the overall force effectiveness results. The study does have limitations, however, particularly in the use of additional tanks to increase fire power. The current trend in the Marine Corps is towards a "lighter" force. The addition of more tanks is an unlikely possibility.

D. CONCLUSIONS

The "revitalized" MTACCS concept intends to establish "work station equipped nodes at every echelon throughout the MAGTF" (underline added) [Ref. 1:p 7]. The MTACCS Master Acquisition Plan provides a communications architecture diagram that implies automation will be provided down to the battalion level at the very least [Ref. 32:p 6-8].

Based on the results of the TCO study, automation of this degree may not be the most cost-effective method of increasing combat effectiveness. The study showed that the Austere TCO performed basically as well as Full TCO. This can lead to the conclusion that the automation of the lower levels is not as effective or not feasible. There may, however, be cause to doubt the applicability of these results to the TCO study. The apparent lack of benefit from full TCO may have been a result of a portability problem that no longer exists. Ten years ago, the capability of portable equipment was minuscule compared with current capabilities. Generally a large heavy piece of equipment was necessary to achieve any significant level of processing capability. TCO was intended to use the same equipment as MIFASS. Recall form Chapter II that the MIFASS equipment was universally recognized as too heavy. The TCO of ten years ago may have overwhelmingly encumbered the lower echelons. The majority of the lower command levels are active participants in "Maneuver Warfare". They shoot and move and stay on the go. Modern data processing and telecommunications technologies, however, have the potential of providing sufficient automation to the lower command levels in a much smaller, much lighter package. These are important issues that should be examined

before such an analysis is used as a justification for a particular degree of automated command and control.

The most significant conclusions to be drawn from this chapter are these:

1. Automation of command and control functions has the potential to significantly enhance the combat effectiveness of the Marine Corps.

2. The proper level of automation may not be "all you can get". The most cost effective level of automation may be that which restricts automation to the higher headquarters; regiments and above.

3. The rapid pace of technological progress in data processing and telecommunications calls into question the applicability of the CNA studies to the TCO and MAGIS systems of today. [Ref. 58:p 11]

VI. COMBAT DEVELOPMENT ASSESSMENT

A. INTRODUCTION

1. Definition of Combat Development

The Marine Corps recognizes that it must continually evaluate its own combat effectiveness and efficiency, and develop guidance and direction that plans the course of the Marine Corps in the years ahead. Planning that course and guiding the Marine Corps along the way, is called combat development. The responsibility for combat development is primarily vested in the aptly named Marine Corps Combat Development Command (MCCDC). There does not appear to be a formal definition of combat development. For the purposes of this assessment, combat development is defined as the evaluation of current combat capabilities and effectiveness and the subsequent planning and implementation of a development effort designed to meet anticipated requirements. Mainly, combat development consists of:

1. Development of concepts, plans, and doctrine.
2. Threat assessment.
3. Development of training requirements.
4. Identification of requirements for changes to doctrine, training requirements, force structure, and equipment.
5. Development of required operational capabilities.
6. Mission Area Analysis. [Ref. 26:p 3-21]

The goal of combat development is to ensure that the Marine Air Ground Task Force of the future will be capable of effectively accomplishing its assigned missions on the battlefields of the future.

2. The Impact of Combat Development on MTACCS

The MTACCS program is a direct result of combat development efforts in the Marine Corps. It was through combat development that the need for MTACCS was determined. Combat development will continue to chart the course of MTACCS throughout its operational life.

3. Objective

The objective of this chapter is to assess the combat development practices used within the Marine Corps that directly impact the MTACCS program. These practices will play a major role in shaping the evolution of MTACCS, and to a large degree, will determine its fate.

4. Lack of Contractor Information

The systems engineering practices used by contractors will also impact combat development in general and MTACCS in particular. Pacific Northwest Laboratories (PNL) is the system engineer and integrator for MTACCS. They have not yet formally published their Systems Engineering Management Plan (SEMP) and a draft could not be attained. Many other contractors including Command Systems Incorporated (CSI) and Atlantic Research Corporation (ARC) are working on various segments of MTACCS. While their methods would be necessarily similar, each undoubtably has their own

individual approach to systems engineering. For these reasons, the systems engineering methodology employed by contractors is considered beyond the scope of this thesis and will not be assessed.

5. Assessment Methodology

Combat Development practices in the Marine Corps are similar to a systems engineering methodology. The objective of both, in the simplest sense, is to develop a "system" that can effectively accomplish its assigned tasks. An assessment of combat development, therefore, can be accomplished through a comparison with established systems engineering techniques. The methodology for assessment, then, consists of the following steps:

1. Describe current Marine Corps combat development practices.
2. Describe the impact of these practices on MTACCS.
3. Define systems engineering.
4. Develop a system view of the Marine Corps.
5. Identify the impact of applying systems engineering to combat development in the Marine Corps.

6. Outline of this Chapter

Section B of this chapter describes in general terms how combat development is currently accomplished in the Marine Corps. Section C describes the impact of combat development practices on MTACCS. In Section D of this chapter, systems engineering is defined and explained. This definition provides the basis for a comparison with combat

development. Systems engineering models are developed to establish a baseline process for effective systems engineering. The models represent an ideal systems engineering effort; everything done correctly. Section E develops a system view of the Marine Corps. In section F, the possible impact of applying a systems engineering methodology to combat development is described.

B. COMBAT DEVELOPMENT IN THE MARINE CORPS

1. The Combat Development Team

The combat development team in the Marine Corps is primarily composed of three organizations: MCCDC, MCRDAC, HQMC. Figure 27 outlines the interrelationships between these activities. The functions and responsibilities of these organizations were described in Chapter III.

a. Marine Corps Combat Development Command (MCCDC)

The Marine Corps Combat Development Command (MCCDC) is tasked with analyzing current and anticipated Marine Corps missions and developing concepts, plans, doctrine, force structure, and equipment requirements to support those missions.

b. Marine Corps Research, Acquisition, and Development Command

The Marine Corps Research, Acquisition, and Development Command, as its name implies, is primarily tasked with managing the research, acquisition, and development of new equipment to meet the needs of the Marine Corps. MCRDAC, then, provides feedback to the Combat Development Command on technological capabilities.

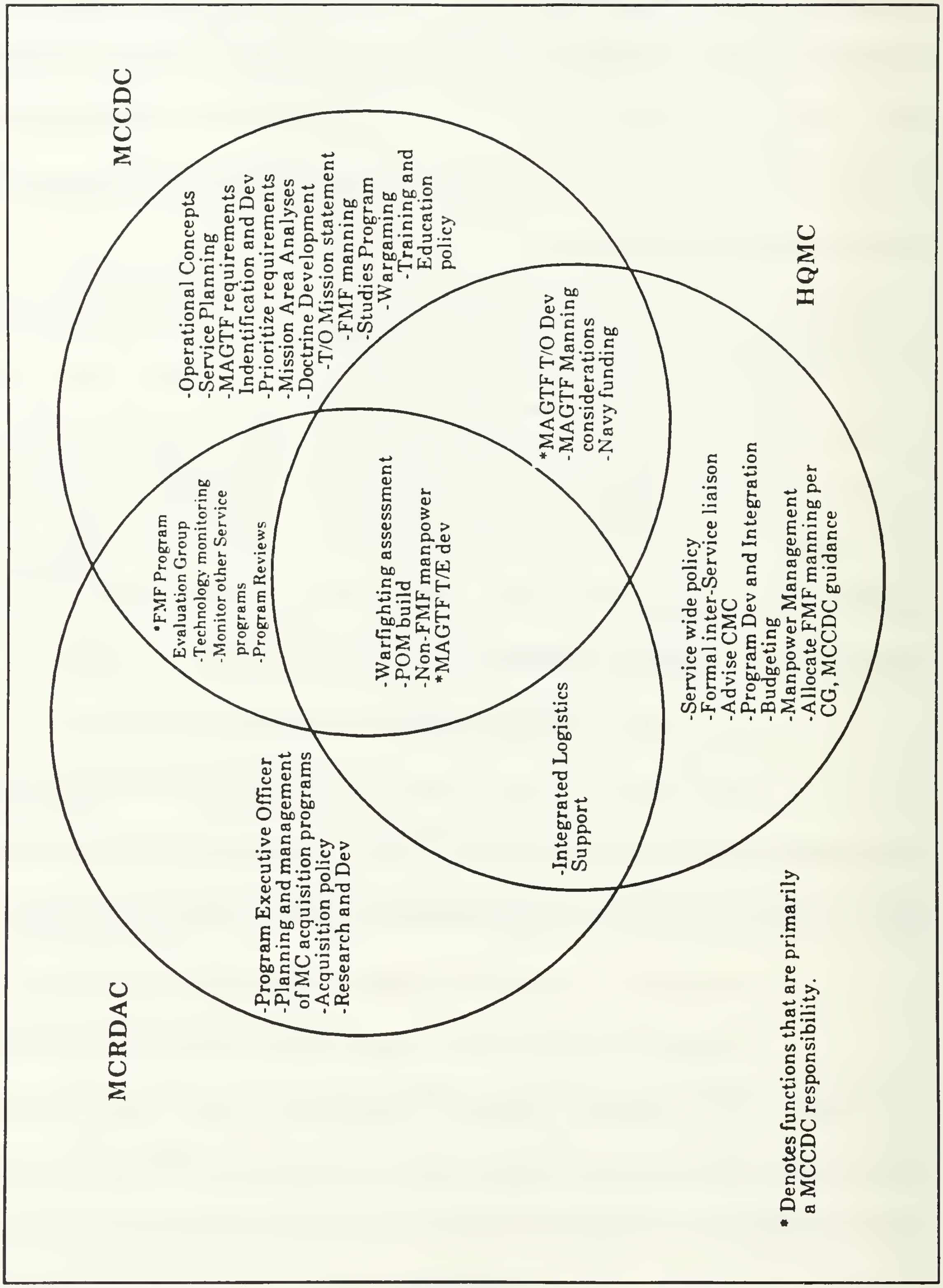

Figure 27: MCCDC, MCRDAC, HQMC Interrelationships [Source: MCCDC]

c. *Headquarters Marine Corps*

Headquarters, Marine Corps sets policy and must approve combat development recommendations.

2. Procedures

Figure 28 provides a brief overview of the combat development cycle. The combat development procedures outlined here are a simplistic, high level representation. Details of activities occurring within the organizations have not been presented. Additionally, a considerable amount of operations analysis is accomplished by activities external to the Marine Corps such as the Center for Naval Analyses.

a. *Mission Area Analyses*

In many cases, the combat development process is initiated by a Mission Area Analysis. This analysis of a particular mission area, such as intelligence or command and control, identifies deficiencies and proposes recommended actions for correction. The combat development process then analyzes and evaluates the recommended solutions. Figure 29 gives a brief description of the process from a Mission Area Analysis to achievement of mission capability.

C. THE IMPACT OF COMBAT DEVELOPMENT ON MTACCS

Combat development is a complex process. The description of combat development presented in the previous section only scratches the surface of a very deep subject. For this reason, the impact of combat development on MTACCS is not entirely clear. There appears to be two trends, however, in the recommendations and decisions that result from

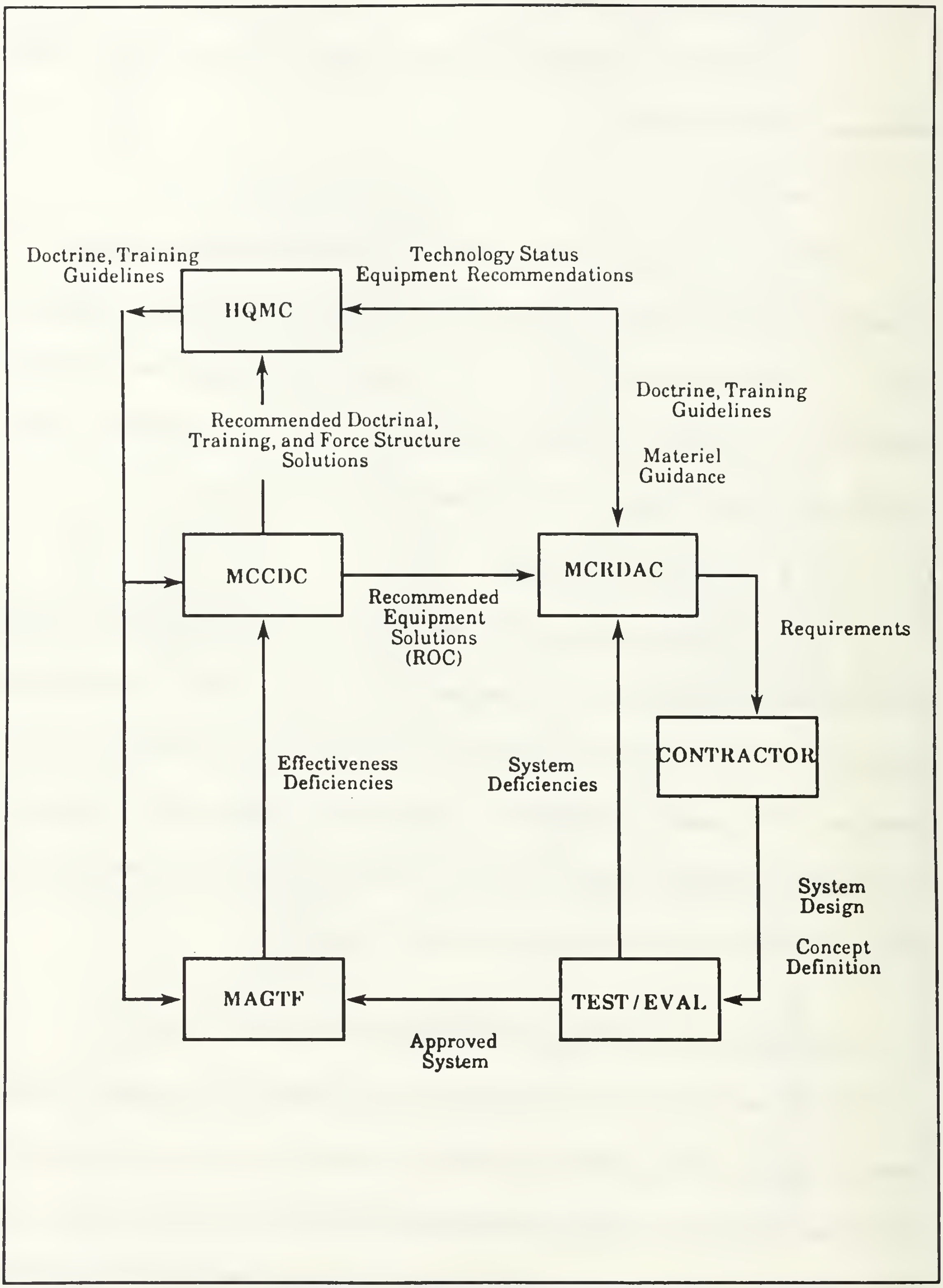

Figure 28: The Combat Development Process [Source: Authors]

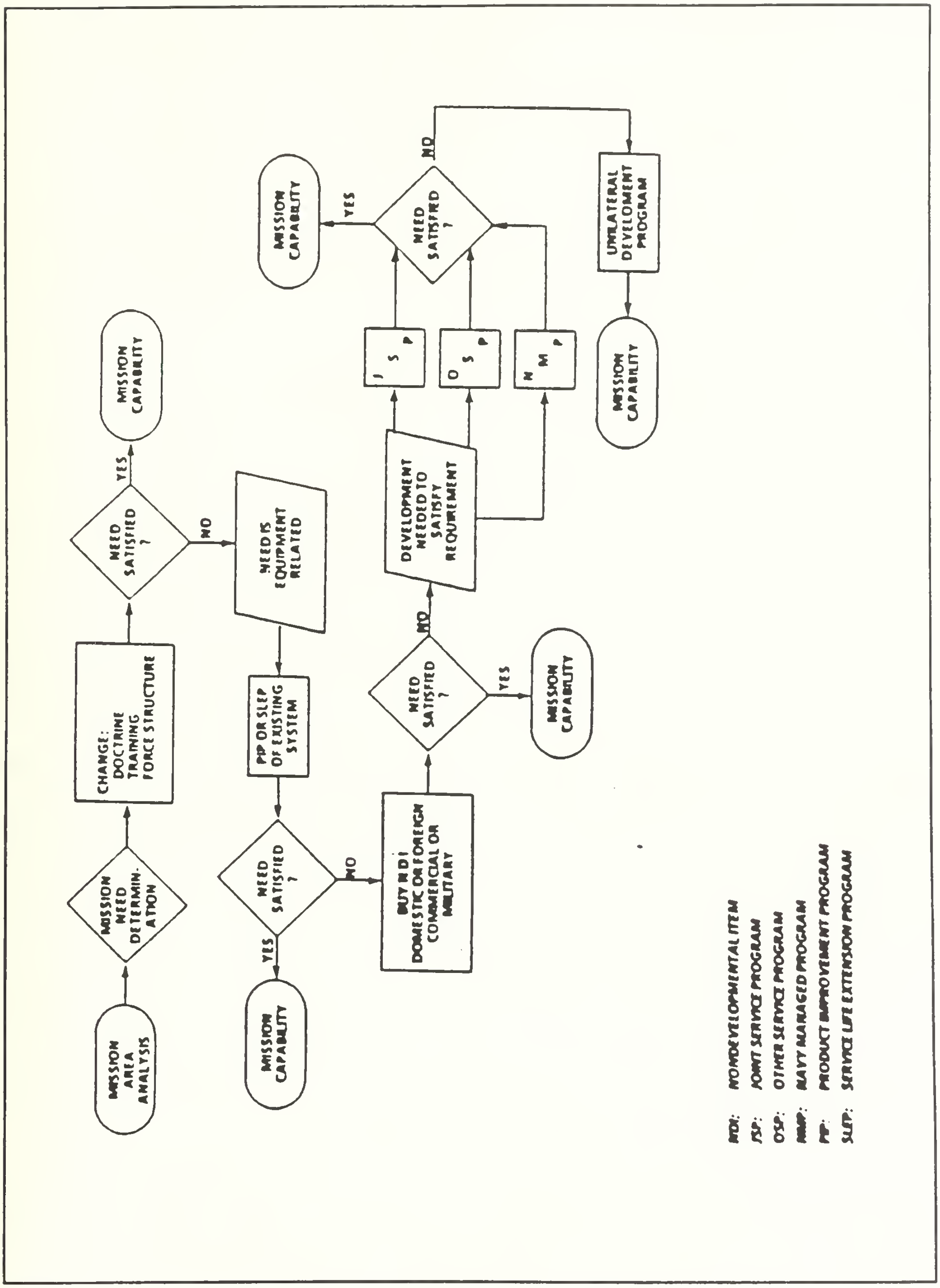

Figure 29: Mission Area Analysis to Mission Capability [Source: Ref. 26]

the combat development process. From these trends, it is possible to generalize on the probable impact of combat development on MTACCS.

1. General Trends

Mission Area Analyses are key contributors to the combat development process. The recommendations that result from Mission Area Analyses, and subsequently from the combat development process, appear to follow two general trends. These trends will likely have an impact on the development of MTACCS.

a. An Equipment Orientation

The majority of recommendations appear to be equipment oriented; relating to improvement of existing equipment or the acquisition of new material or equipment. An examination of two recently completed Mission Area Analyses revealed that recommendations for materiel changes were most common. In an analysis of fire support deficiencies, materiel recommendations were offered as the solution to 15 of the 29 noted deficiencies. [Ref. 60] Another Mission Area Analysis for assault support recommended materiel changes as at least part of their proposed solutions to 22 out of 28 priority deficiencies. [Ref. 61]

The possibility of an equipment or materiel orientation is not surprising. The requirement for Mission Area Analyses has its roots in the Office of Manpower and Budget (OMB) Circular A-109 which requires any major new system acquisition be preceded by an analysis of the mission. [Ref. 62] Mission Area Analyses were

intended from the very beginning to provide evidence to support the acquisition of new equipment.

The development of MTACCS will also emphasize materiel and equipment solutions. MTACCS will not change the organization or structure of the MAGTF. Only procedures will be modified to some extent as tasks are automated. [Ref. 32]

b. Basic Recommendations

A second trend appears to be that the recommendations that result from the combat development process are only basic recommendations that do not offer integrated solutions. A basic recommendation may only address one element of the entire system, whereas an integrated recommendation might address a requirement for changes in several elements of the system. A "basic" recommendation for a communications deficiency, for example, might be to buy another radio. An "integrated" recommendation might be to adjust procedures to cut down on traffic requirements, reorganize the unit to allow for alternate communications paths, and reallocate traffic to alternative systems. The basic recommendation may be the best solution at times, but probably not all the time. The recommendations in Mission Area Analyses are rarely, if ever, as involved as the example of an "integrated" recommendation shown here.

The process shown earlier in Figure 29 also fosters a basic approach to solutions. While the process diagram is necessarily simplified, it implies that solutions to a deficiency can be categorized as either training, doctrine, and force structure

recommendations <u>or</u> equipment recommendations. The diagram does not foster the idea of integrated solutions.

In some sense, MTACCS is a basic recommendation as well. While the integration of component systems will be enormously complex, the underlying concept is relatively basic: automate tasks that are currently being done by manual systems, and allow those automated systems to share information. No attempt will be made, at least initially, to modify force structure or doctrine in concert with materiel procurement.

2. Command and Control System Trends

The development of command and control systems within DOD in general also appears to follow certain trends that are described here.

a. Use of an "Applique Approach" for C^2

It appears to be a general trend in the military to acquire weapons systems first and then devise the command, control, and communications as an accessory [Ref. 63:p 5]. This method of development has been referred to as an "applique approach" [Ref. 64:p 17]. This approach can be sufficiently effective when the complexity of the system is relatively low. Command and control of what essentially amounts to the entire Marine Corps, however, is not low on the complexity scale.

The Strategic Defense Initiative (SDI) is one example of a highly complex system with software challenges of unprecedented magnitude. In addressing the command and control of SDI, one report stated:

> The trade-offs necessary to make the software task tractable are in the system architecture...the "applique approach" of designing the system first and then writing

> the software to control it is the wrong approach for SDI. System architecture and battle management must be developed together. [Ref. 63:p v]

The MTACCS program appears to follow an applique approach as well. The MAGTF structure, doctrine, and communications have been set and MTACCS hardware and software will be applied as an accessory. As with SDI, the trade-offs necessary to make software development more manageable might be found in modifications to force structure, doctrine, or the communications architecture. It appears, however, that these elements of the Marine Corps system will not budge.

b. Standardization is More Important than Optimization

In the age of a seemingly boundless integration of transistors onto a single chip, merely coping with technology is consuming a majority of our efforts. Many in the military have virtually abandoned the idea of optimizing and are now simply trying to get their systems to work. Lieutenant Colonel C. Kenneth Allard, USAF, emphasized this point in his book <u>Command, Control, and the Common Defense</u>:

> The dominant issue in establishing a telecommunications path is not its optimization but standardization of the process. More important than doing things the best way is doing them the same way. [Ref. 30:p 17]

MTACCS, too, may suffer from this plight. The challenge of "just getting it to work" is enormous. The complexity and volume of interfaces is so large, that the first priority appears to be establishing a demonstration model to field a limited capability. Optimizing appears to be a lesser concern.

D. A DESCRIPTION OF SYSTEMS ENGINEERING

1. Introduction

Combat Development has much in common with systems engineering. This section develops a description of systems engineering to serve as a framework for comparison.

2. Definition

A system is defined as a collection of elements organized to perform a set of designated functions in order to achieve a specific result. The elements which comprise a system include personnel, material, equipment, facilities, procedures, and information. The approach used to plan and design a system in its entirety is called systems engineering. The goal of systems engineering is to plan and design a system as an entity in order to satisfy the needs of the user. [Ref. 65] Effective systems engineering makes the successful operation of all subparts guarantee that the assemblage will perform the tasks for which it was intended. Many systems fail to accomplish what was expected due to inadequate, biased, or misleading communications between the system designers and the users. [Ref. 22:p 3]

There are many definitions of systems engineering. The terms "systems engineering" and "systems engineering management" are often used interchangeably and the difference between them is occasionally blurred. Systems engineering can be defined as the application of scientific and engineering efforts to:

1. Transform an operational need into a description of system parameters and a system configuration through the iterative process of definition, synthesis, analysis, design, test, and evaluation.

2. Integrate related technical parameters and assure compatibility of all physical, functional, and program interfaces in a manner which optimizes the total system definition and design.

3. Integrate reliability, maintainability, safety, survivability, human and other such factors into the total engineering effort to meet cost, schedule, and technical performance objectives. [Ref. 66]

The Defense Systems Management College concentrates on management aspects and defines systems engineering as the management function that controls the total system development effort for the purpose of achieving an <u>optimum balance of all system elements</u>. It is a process which transforms an identified operational need into a description of system parameters and integrates those parameters to optimize the overall system effectiveness. [Ref. 67:p 1-2]

For the purposes of this thesis, systems engineering is composed of two elements, the engineering process and the management of the overall engineering effort. The systems engineering process consists of the steps and procedures used to define, design, and develop the system. Systems engineering management consists of the activities and decisions that control the process of the engineering effort. The systems engineering process is described in detail in the following sections. It is this description that will serve as a basis for comparison with combat development.

3. The Systems Engineering Process

a. Definition of the Systems Engineering Process

The systems engineering process is oriented toward system analysis, design, and definition. A sequential process is depicted in Figure 30. [Ref. 65:p 43] This figure represents the model that will be used in the systems engineering assessment. The process is defined in terms of tasks to be performed somewhat sequentially.

b. A Systems Engineering Process Model

The systems engineering process model consists of the steps depicted in Figure 30. Each step has several functions to be accomplished before the next step can be completed.

(1) Requirements Analysis. A major problem with many systems is that the reasons to build the system do not necessarily fill operational requirements. The requirements analysis examines the current threat and mission needs. Once the needs have been validated to meet the threat, system performance requirements are defined. Utility functions are created to provide a method (a value system) to compare disparate characteristics of different systems on a relatively equal basis. The choice of the system to pursue is decided on the basis of a weighted decision matrix. Characteristics are evaluated and weighted and each system's characteristics are measured. The alternatives with the highest scores are considered for further development. This is the key step of the system engineering process: translating mission requirements into system performance and design requirements. [Ref. 65]

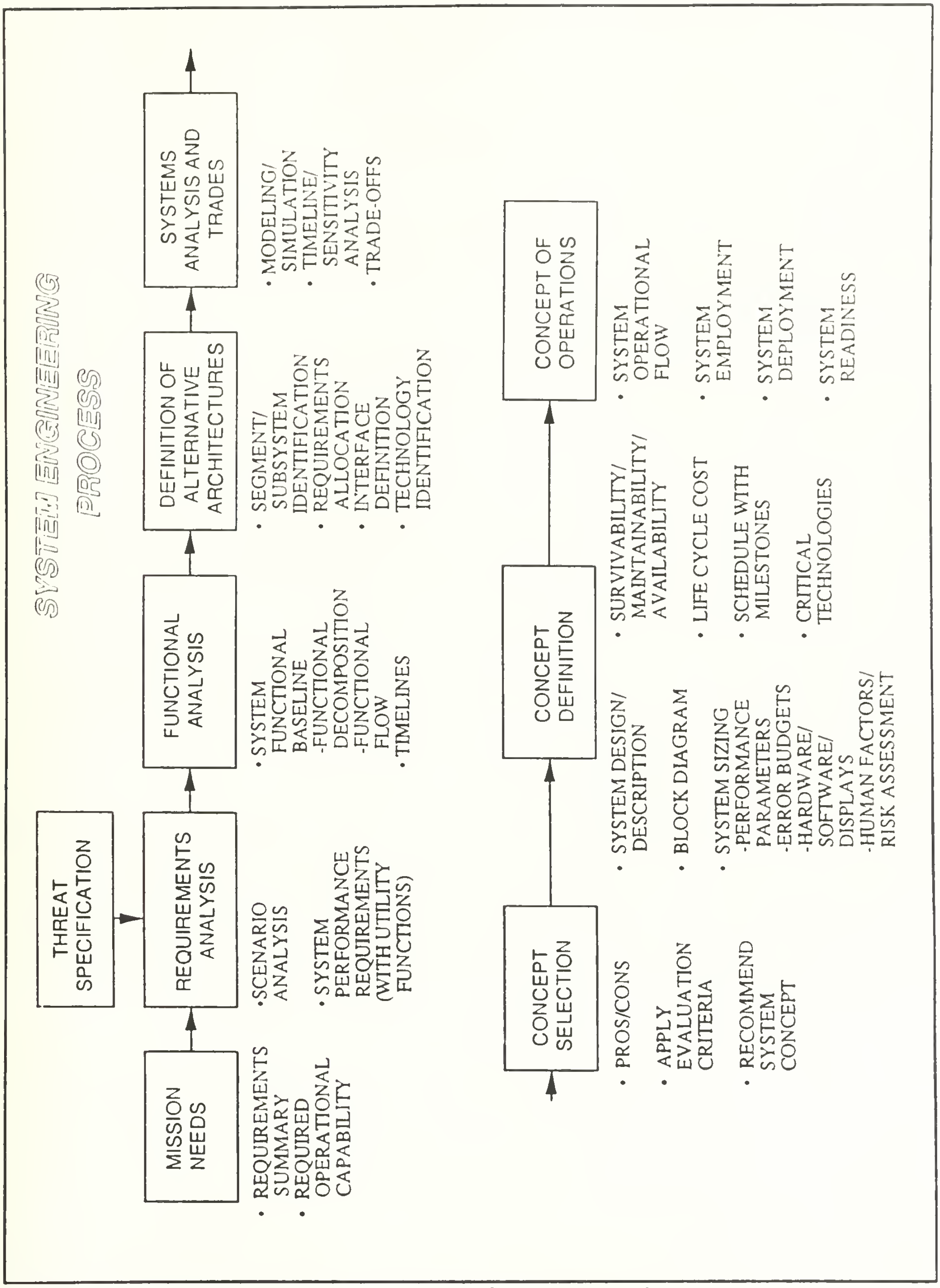

Figure 30: Systems Engineering Process [Source: Ref. 65]

(2) Functional Analysis. Functional analysis is a method for analyzing performance requirements and dividing them into discrete tasks or activities. It involves the identification and decomposition of the primary system functions into subfunctions at ever increasing levels of detail to establish a baseline of the functions that must be performed in order to satisfy system requirements. [Ref. 67:p 6-1]

Three levels of functional decomposition are generally performed to provide enough description to suggest alternative architectures for evaluation. Figure 31 depicts these three levels. The top level (level 0) functional flow diagram shows a general overview of the activities performed during the mission. The second level (level 1) shows the functions that are done in each activity. The third level (level 2) breaks down in greater detail the actions that are performed for each function in level 1. After a concept has been chosen, the functional decomposition will be broken down further to reflect a particular design. [Ref. 65:p 21]

(3) Definition of System Alternative Architectures. An architecture is a statement of what is required to accomplish the mission. The statement includes the hardware, software, personnel, and operational items to be used. "It is the allocation of system functions among defined system elements." [Ref. 65:p 23]

Since there are a number of ways to accomplish the same task using different technologies, procedures, or equipment, a study of several different methods must be accomplished to determine the optimal solution. This study must measure each individual system, on its own merits, in the accomplishment of the requirements.

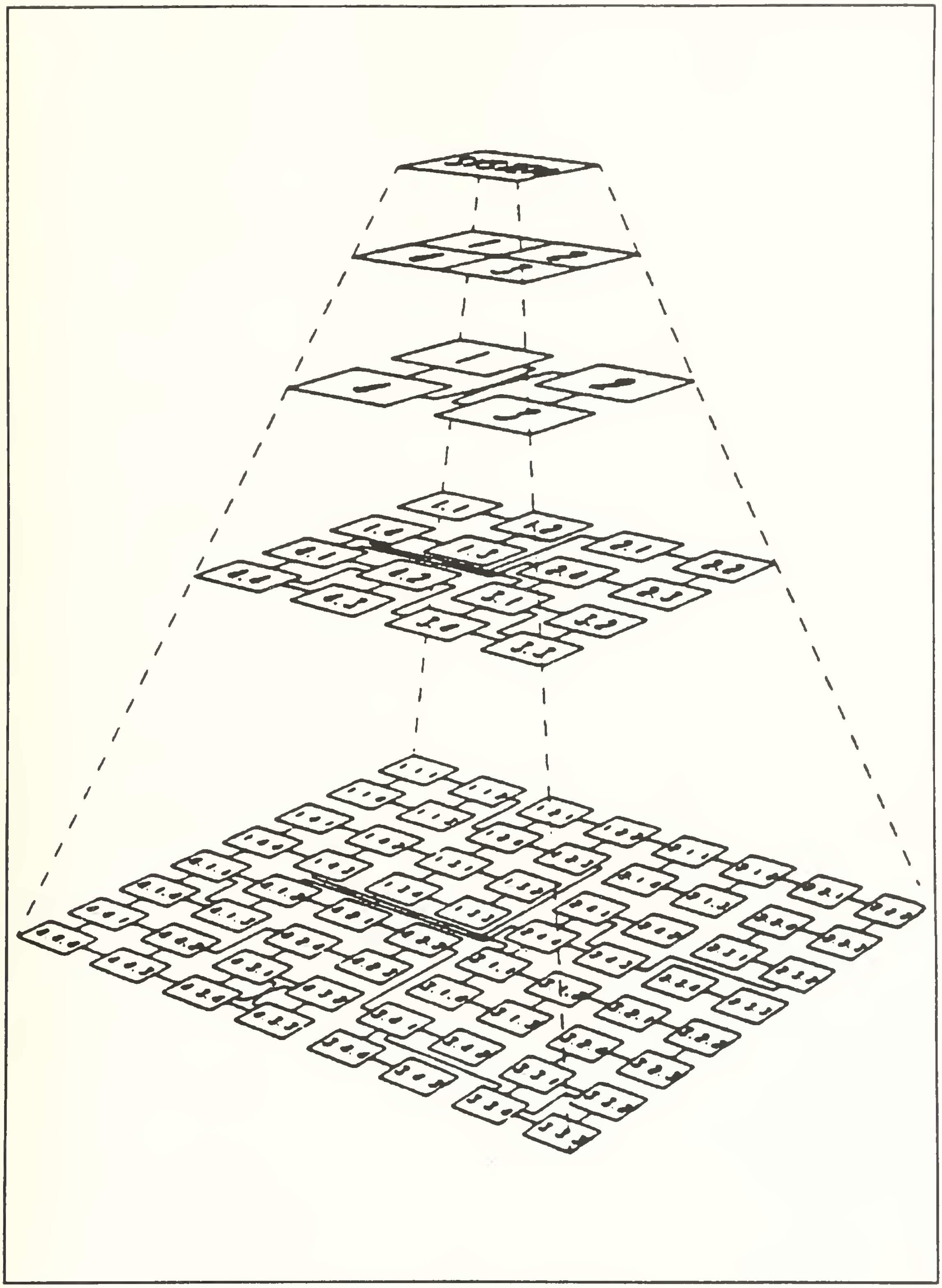

Figure 31: Functional Decomposition [Source: Ref. 67]

Normally this would be accomplished through a value system of some kind. [Ref. 65:p 24]

(4) Concept Evaluation and Selection. There are three steps to concept evaluation and selection. The first is to synthesize and refine the alternative architectures through a series of trade studies. The second step is concept selection. Based on the results of the trade studies and the weighted decision criteria described in the requirements analysis, the most promising system or concept is selected for further development. The results from the trade studies and the utility functions consisting of the decision criteria should have sensitivity analysis conducted for each system or concept. Small changes in performance, especially when the final scores are close, may change the optimal solution. A review of the scores will usually reveal a few key decision criteria that drive concept selection. [Ref. 65:p 30]

The final step is concept definition. Concept definition takes the selected concept and formally defines its performance, physical configuration, and critical technologies. Performance parameters, error budgets, hardware and software specification, and human and machine interfaces are some examples of the areas that contribute to the system's composition. Human factors engineering must play a vital role to ensure the system can be operated effectively, especially during periods of high stress. Survivability, maintainability, and availability criteria are delineated at this point. The final part of concept definition is a systems engineering management schedule with milestone decision points. [Ref. 65:p 30-35]

(5) Concept of Operations The Concept of Operations is written by the operational using command. It consists of a time sequenced narrative of system operations, system employment and deployment, and system readiness. [Ref. 65:p 35-36]

E. A SYSTEM VIEW OF THE MARINE CORPS

The Marine Corps is a highly complex organization; a "Band of Brothers" bound by tradition, esprit de corps, honor, loyalty, and patriotism. A system view of the Marine Corps can not provide a complete portrayal of the intricacies of America's warrior elite. It is useful and necessary for the purpose of this assessment, however, to reduce the complexities of combat development to a manageable, simple representation. There are several ways to represent combat development in varying levels of detail. The alternative chosen in this assessment is to view the entire Marine Corps as an enormous "system" designed to develop combat power and efficiently translate that power when necessary into combat force effectiveness. The system is composed of Marines and their organizations, weapons and equipment, and procedures and standards.

Headquarters Marine Corps, the Marine Corps Combat Development Command, and the Marine Corps Research, Development, and Acquisition Command together, essentially serve as the systems engineering team for the Marine Corps. They manage the total system development effort within the Marine Corps to achieve an effective balance of all system elements. That balance is optimal when the combat effectiveness of the Corps is maximized within given resource constraints. The organization and procedures used to

achieve that optimal balance are absolutely vital to the success and future of the Marine Corps.

Essentially, MCCDC serves as the systems engineer for the Marine Corps. The Commanding General of MCCDC has been assigned the responsibility of ensuring that the Marine Corps functions smoothly as an effective, integrated system and can accomplish its assigned missions.

In many respects, MCCDC carries out a ***systems engineering process*** in the development of concepts and requirements.

In a very basic sense, MCRDAC serves as the systems engineering management team for the Marine Corps. The Commanding General of MCRDAC has been designated as the Program Executive Officer (PEO) for the Marine Corps. As such, he has the responsibility, authority, and accountability for all Marine Corps acquisition programs.

Basically MCRDAC carries out a ***systems engineering management process*** in the development of systems that are components of the overall Marine Corps "system".

F. THE IMPACT OF APPLYING SYSTEMS ENGINEERING TO COMBAT DEVELOPMENT

Applying a more rigorous scientific methodology to combat development has both positive and negative aspects.

1. Positive Aspects

If systems engineering is properly applied to combat development, several potential benefits exist. The most important benefit could be a more effective Marine

Corps; a Marine Corps that is capable of achieving a greater level of combat effectiveness within the same resource constraints. This greater effectiveness would be the result of attempts at balancing all of the elements of the system to maximize overall combat effectiveness. The trends mentioned earlier could be mitigated or eliminated entirely.

An effective systems engineering methodology would also promote the idea of examining other elements of the system as potential solutions to any identified deficiencies. In the MTACCS program, for example, software development is seen as a significant challenge. One hypothetical method of reducing the software complexity can be found in altering force structure or procedures. In this example then, the difficulty in implementing the equipment portion of the overall solution is lessened through the implementation of change in other elements of the system.

2. Negative Aspects

Negative aspects include the likelihood of a lengthier and more costly combat development process. Complex "integrated" recommendations would be far more difficult to generate, evaluate, and validate. Considerable resistance to changes in doctrine and structure is almost a certainty. In addition, "integrated" recommendations have the appearance of the "big system approach." While "big system approach" has no formal definition, it appears to consist of two aspects. The first is an emphasis on complete development of a fully functioning system in one big step. The second aspect involves simultaneous modifications to several elements of the system. The MIFASS program, for example, intended to implement significant modifications to doctrine, equipment, and

procedures all at the same time. The experience of the MIFASS system has brought great disfavor on "big system approaches" that affect many facets of the Marine Corps system.

G. CONCLUSIONS

1. Little Faith in the "Big System Approach"

The failure of MIFASS has caused the Marine Corps to have little faith in the "big system approach." This is unfortunate because it appears that the chosen alternative is a tendency toward evolutionary development of only one element of the Marine Corps system at a time: change some equipment, for example, and keep all other system elements relatively static. The trend towards evolutionary development appears to be beneficial; whereas the reliance on basic solutions that address only equipment, for example does not. While basic solutions are less complex, they trade a great deal of effectiveness away to achieve that lower level of complexity. Regardless of the bad experience of MIFASS, there remains a need to implement change in a manner that integrates all of the elements of the system.

2. The Need for Systems Engineering in the Marine Corps

As described earlier, the Marine Corps' "system" is composed of three basic elements: people and organizations, weapons and equipment, and procedures and standards. Ideally, these elements are optimally proportioned and structured. Manpower levels, types and quantities of equipment, operating procedures, and such, have been carefully chosen to maximize the overall effectiveness of the system within the resource constraints imposed.

Revolutionary advances in any one of the elements can dramatically improve system effectiveness, but the new proportion or structure may no longer be optimal. Modifications to doctrine, procedures, or force structure, for example, may better complement a major advance in weapons technology that the current doctrine, procedures, or force structure. If no complementary modifications are made, effectiveness may be less than the maximum possible within a given level of resources. This equates directly to wasted resources. In some cases, advances in one element may even be countered by out of date practices in another element.

In recent years, revolutionary advances have occurred most often in the development of weapons and equipment. Users and developers alike are tempted to solve most deficiencies with new technology. New technology alone, however, focuses on only one element of a complex system. Equal attention must be given to all elements of the system to ensure optimal use of resources.

Robert Everett also believed that new technology should not merely be used to support a static organizational structure. Addressing the role of technology in the organization, Everett wrote:

> The problem with the staff is not how to support the staff, but how to get rid of the staff.... [Ref. 40:p 24]. To take advantage of distributed C^3 we must learn how to distribute the staff function itself, how to separate the peacetime from the wartime, and how to use computers to support the commander directly rather than the commander's staff.... Much work needs to be done on finding ways to replace all kinds of people with machines in carrying out C^3 functions. [Ref. 40:p 23]

Clearly Everett promotes the simultaneous evolution and integration of staff (Marines and their organizations), procedures, and technology (weapons and equipment).

In managing the Marine Corps as an enormous system, the systems engineering team must employ a scientific approach in order to efficiently maximize combat effectiveness. The Marine Corps must evolve continuously using these scientific methods as tools to direct its own evolution.

3. The Impact of Continuous Evolution

Continually balancing the elements of the system implies a continual reorganization. Frequent reorganization, however, is viewed by most Marines as more of a malady itself than as a cure for effectiveness shortfalls. When the "spectre" of reorganization raises its ugly head, few embrace it with enthusiasm. It is true that reorganization and changes in doctrine can disrupt the continuity within a command and degrade performance, at least initially. Changes such as these are frequently cited reasons for a lack of cohesion within a unit.

Marines, like everyone else, are creatures of habit; more comfortable with routine than chaos. Adaptability and flexibility, however, are vital to the success of the Corps. In the midst of revolutionary advances in weapons, computers, and communications, the remaining elements of the system cannot remain static. They must keep pace. In reflecting on the relationship of technology to command in his book Command in War, Martin Van Creveld wrote:

> ... The most important conclusion of this study may be that there does not exist, nor has there existed, a technological determinism that governs the method to be selected for coping with uncertainty. At various periods in history, and in the face of any one set of requirements arising from the art of war as exercised in those periods, different military organizations, though making use of the same general communications and data processing capability, have approached the problem from radically different angles with radically different results. There was nothing in the

nature of any single technology, whether based on the *signum* or on the telephone, the messenger or the computer, to dictate which of two solutions should be adopted.

> Far from determining the essence of command, then, communications and information processing technology merely constitutes one part of the general environment in which command operates. To allow that part to dictate the structure and functioning of command systems, as is sometimes done, is not merely to become the slave of technology but also to lose sight of what command is all about. Furthermore, since any technology is by definition subject to limitations, historical advances in command have often resulted less from any technological superiority that one side had over the other than from the ability to recognize those limitations and to discover ways - improvements in training, doctrine, and organization - of going around them. Instead of confining one's actions to what available technology can do, the point of the exercise is precisely to understand what it cannot do and then proceed to do it nevertheless. [Ref. 40:p 274-275]

4. The Point of This Chapter

The principle theme of this chapter is this: while technology is capable of marvelous achievements, it continues to be only a part of a larger system. To make optimal use of technology does not necessarily maximize the effectiveness of the system as a whole. Each element, the personnel, procedures, and technology, of the system must be properly balanced to achieve that maximum effectiveness. In his book Technology and War, Martin Van Creveld wrote:

> ... let us turn to the first paragraph on the first page in the first chapter of Clausewitz's On War. Here, armed conflict is defined as an act of violence where each side is out to destroy the other. This makes it into the province of hardship and of suffering, of stress and fear, and pain and death. ... war is, therefore, primarily an affair of the heart. It is dominated by such irrational factors as resolution and courage, honor and duty and loyalty and sacrifice of self. When everything is said and done, none of these have anything to do with technology... so it was at a time when war was limited to face to face clashes between hide-clad, club-armed cavemen 50,000 years ago; so it will be when laser firing flying saucers permit it to be fought over interplanetary distances 100, or 500, or 1,000 years hence. [Ref. 68:p 313-314]

Adherence to a systems engineering process in combat development has the potential of mitigating some of the current trends and restoring the oft neglected elements of the system to their proper levels of emphasis. The trend toward an equipment orientation, for example, can be lessened if modifications to doctrine, force structure, procedures, and such, are more readily accepted as candidate solutions.

VII. MTACCS INTEROPERABILITY ASSESSMENT

A. INTRODUCTION

1. Objective

The purpose of this chapter is to describe the problems encountered in achieving interoperability in past programs and assess the direction MTACCS is taking towards interoperability.

2. Methodology

From the very beginning, the developers of MTACCS have encountered great difficulty in their efforts to obtain interoperability among the MTACCS subsystems. This chapter begins with a review of the interoperability problems of the past and then follows with a description of the current efforts to enhance interoperability. It then concludes with an assessment of those efforts.

3. A History of Interoperability Problems

a. Historical Reasons for Interoperability Problems

(1) Management Redundancy. Historically, the Department of Defense has tasked numerous agencies and organizations, as shown in Figure 32, with the development of interoperability standards. This has led in some cases to ambiguities in responsibility and authority for standards. There is no "czar" that could manage interoperability. There is a forum, the Military Communications-Electronics Board

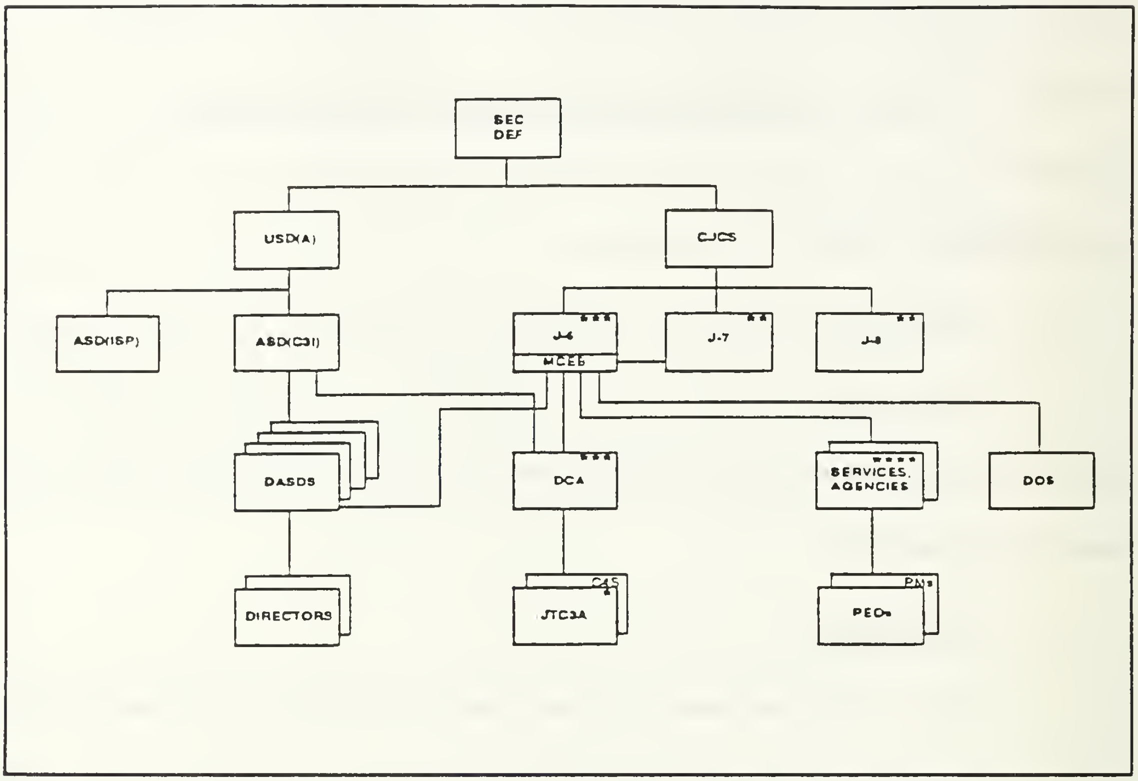

Figure 32: Organizations involved in Interoperability [Source: Ref. 69]

(MCEB), at which many of the key organizations meet. However, this board is not equipped to resolve interoperability issues in a timely fashion. The Joint Tactical C^3 Agency (JTC^{3}A) was established to enhance interoperability at the theater/tactical level. The JTC^{3}A, however, mat not be an effort of sufficient strength. Dr. Stuart Starr of the MITRE Corporation has written:

> (JTC^{3}A) has limited influence, is under-resourced, and tends to be reactive rather than proactive... The key role in interoperability management devolves to the Service Program Executive Officers (PEO's) and the Program Managers (PM). [Ref. 69:p 5-6]

In a few large scale programs[33], such as NIS, WIS, and TRI-TAC, attempts were made to consolidate authority and centralize development in an effort to coordinate interoperability. Although the performance of these organizations varied, there were several areas of relative consistency. In general, the organizations were too slow, too expensive, and resulted in little success. [Ref. 71:p 8]

Since there is no central organization to establish DOD interoperability standards that are directive in nature, the responsibility for interoperability falls on the program manager. However, the program manager tends to be narrowly focused and the top priorities for many programs have been performance, schedule, and cost. Little effort has been expended to design interoperability into a program at its inception. Insufficient effort has been made to coordinate cross program adjustments when configuration changes were made. Proper emphasis has not been given to interoperability. [Ref. 69:p 8]

(2) Architectural. C^3 systems are characterized by many interfaces that are complex, frequently changing, difficult to predict, and occupy many levels. A broad architectural vision must be established early to achieve and maintain interoperability. This vision must state clearly the relationship between systems. In the past there has been

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[33] The NATO Identification System (NIS) is developing the next generation query and response system to support NATO's need for interoperable target identification capability. The World Wide Military Command and Control System (WWMCCS) Information System (WIS) was to modernize key facets of WWMCCS. TRI-TAC was chartered to develop a family of interoperable communications systems for the military.

no vision and architectures, if developed, were generally not continually adhered to. [Ref. 69:p 6]

MIFASS, for example, had a very general vision and did not adhere to the stated architecture. When changes to the architecture were made, there was little coordination among the other MTACCS subsystems.

(3) Proliferation of Standards. In order to be interoperable, the system must be configured to a single set of compatible standards. Currently, there are several agencies and directives developing and setting standards. This makes it difficult to determine the proper set of standards and building to "a" standard does not necessarily guarantee interoperability. [Ref. 71:p 8]

(4) The Expense of Backward Compatibility with Fielded Systems. Backward Compatibility entails enabling the system to be interoperable with older, fielded systems. Interoperability can be achieved through any suitable method, and need not be restricted to technological changes. These older systems usually utilize outdated technology, behind that being fielded in the new system. The Department of Defense has already invested an immense amount of money in C^2 system development and fielded a number of systems. Achieving backward compatibility can be extremely difficult and expensive. In addition, there are many unique systems within the different services. Because of their unique nature, these systems tend to be limited in their capability to interoperate with other systems. [Ref. 71:p 8]

(5) Lack of Standard Testing Policy. Another common source of interoperability problems, is the manner in which systems are tested. As depicted in Figure 33, each service maintains testing agencies of its own. Additionally, many civilian testing and verification agencies and contractors are also used. There does not seem to be a central manager or overseer who can direct testing efforts in a singular direction nor is there a central repository of interoperability standards and information to serve as a baseline for testing. [Ref. 69:p 8]

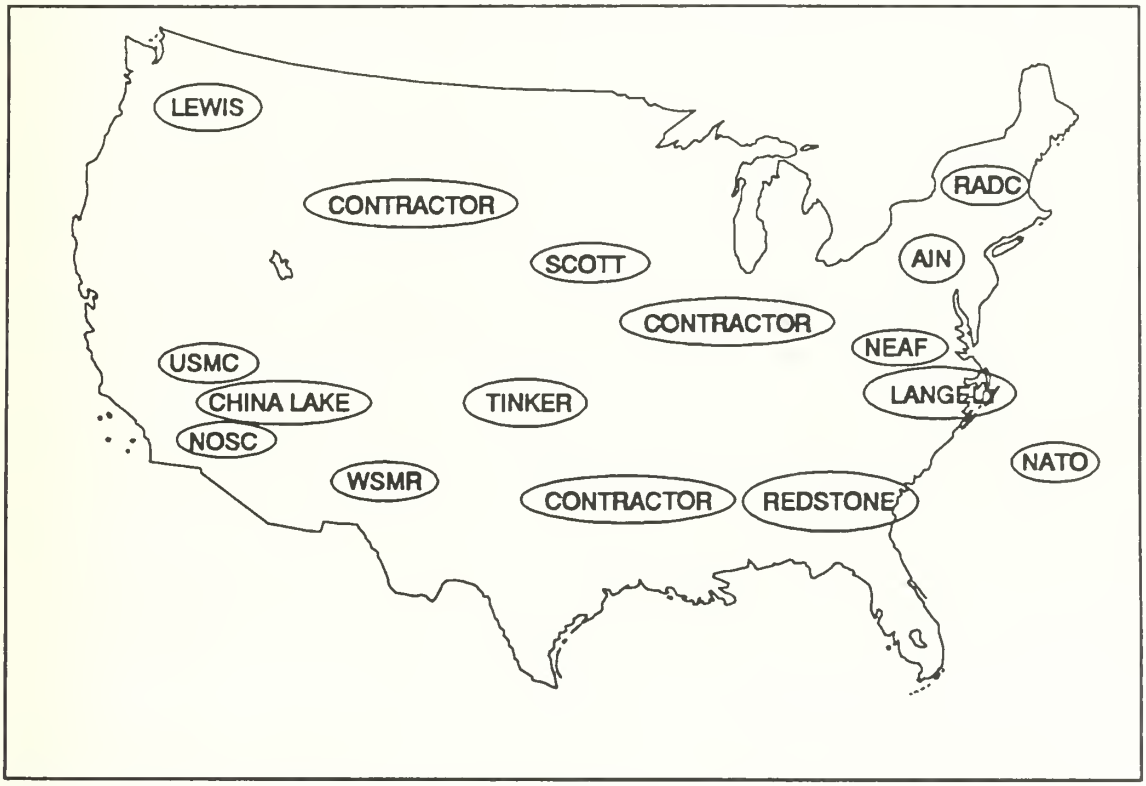

Figure 33: Test Facilities [Source: Ref. 69]

b. Examples of Prior Interoperability Problems

It has been noted previously that MTACCS was originally conceived as a "conceptual association" of systems. That definition, combined with weak configuration management, bred interoperability problems of immense proportions. The problem was particularly acute in the MIFASS program. By 1987, the Institute for Defense Analyses declared that "MIFASS would have little commonality with any other MTACCS system." [Ref. 12:p E-20] The development of protocols for the Unit Level Message Switch[34] (ULMS), for example, was neither coordinated with MIFASS nor with the other systems it was to support. MIFASS was developed with different message protocols and was incompatible with the ULMS. MIFASS was also incompatible with both the Position Location Reporting System (PLRS) and the Digital Communications Terminal (DCT). Work around solutions were required in order to provide common modes of operation. [Ref. 43:p 31]

B. INTEROPERABILITY

1. Definition of Interoperability

As defined in JCS Pub 1-02, interoperability is:

> ... the capability of systems, units, or forces to provide services to, and accept services from other systems, units, or forces, and to use the services so exchanged to enable them to operate effectively together. It is achieved among communications-electronics equipment when information or services can be exchanged directly and satisfactorily between equipment and/or users. [Ref. 70:p 190]

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[34] The primary switching device for message transmission between command and control centers.

In simpler terms, interoperability is the ability to exchange data in a prescribed manner and to use extracted information from that data to operate together effectively [Ref. 71:p 3]. The information that is passed must be understandable to the receiver.

Interoperability can be achieved through manual or automated methods. It can be designed into a system from inception or added as an applique after the system is fielded. Designed-in, automated interoperability requires that emphasis be placed in the four basic elements of interoperability.

2. Elements of Interoperability

There are four basic elements in achieving automated interoperability.

1. Technical Interface Standards. These involve the "electrical engineering" aspects of the problem. This includes the interfaces among the data systems, modems, and receivers/transmitters as well as the waveforms and modulation designs.

2. Message Standards. These are the data elements, data items, and individual message formats in which data is to be transmitted between operators.

3. Operating Procedures. These refer to the procedures to be followed by data system operators in the establishment of data links and exchange of tactical data. These procedures should not be confused with the broader set of *operational* procedures that guide tactical actions.

4. Database and Applications Program Standards. These define variable formats that represent information that is stored and processed in the system. [Ref. 69:p 2]

As depicted in Figure 34, the four elements must be negotiated between programs. In addition to the four elements listed above, thoroughly tested configurations,

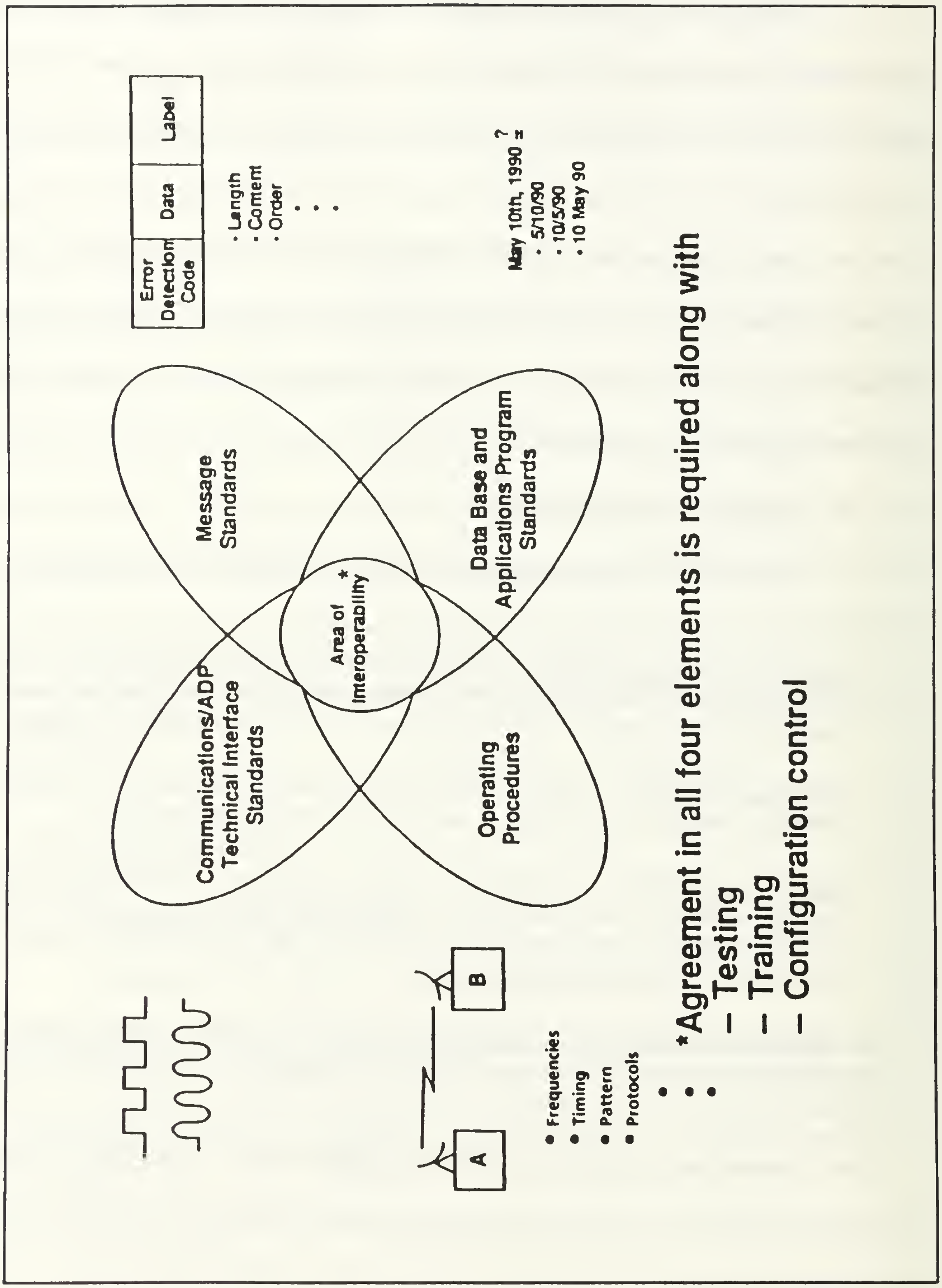

Figure 34: Elements of Automated Interoperability [Source: Ref. 69]

well trained operators, and configuration control (or management) of interfaces, are required to achieve interoperability. [Ref. 71:p 4]

3. Methods of Interoperability

> The level of interoperability sought should be derived from careful assessment of the potential benefits and liabilities based on a broad and deep understanding of mission needs and program constraints. [Ref. 69:p 5]

Figure 35 depicts four of the five basic methods of interoperability. These methods describe ways to achieve a level of automated or manual interoperability. Any one of these methods can be the "best" solution for the situation, depending on the needs, goals, and resources available.

The "swivel chair" and liaison team methods are quick, flexible, and initially, relatively inexpensive. These are generally best in temporary situations when organizations who normally do not work together are forced to interoperate during a conflict or exercise. Common modes and gateways are more "after the fact" interoperability fixes. These methods are generally applied to systems that are well along in their development or are actually fielded. Same system interoperability is accomplished in the design and development of a system. They are designed with the elements of interoperability being compatible. It is important to keep in mind that 100% interoperability with everyone is neither achievable nor necessary. The disparity in methods, systems, and political preference is a challenging obstacle to overcome when determining the appropriate level of interoperability.

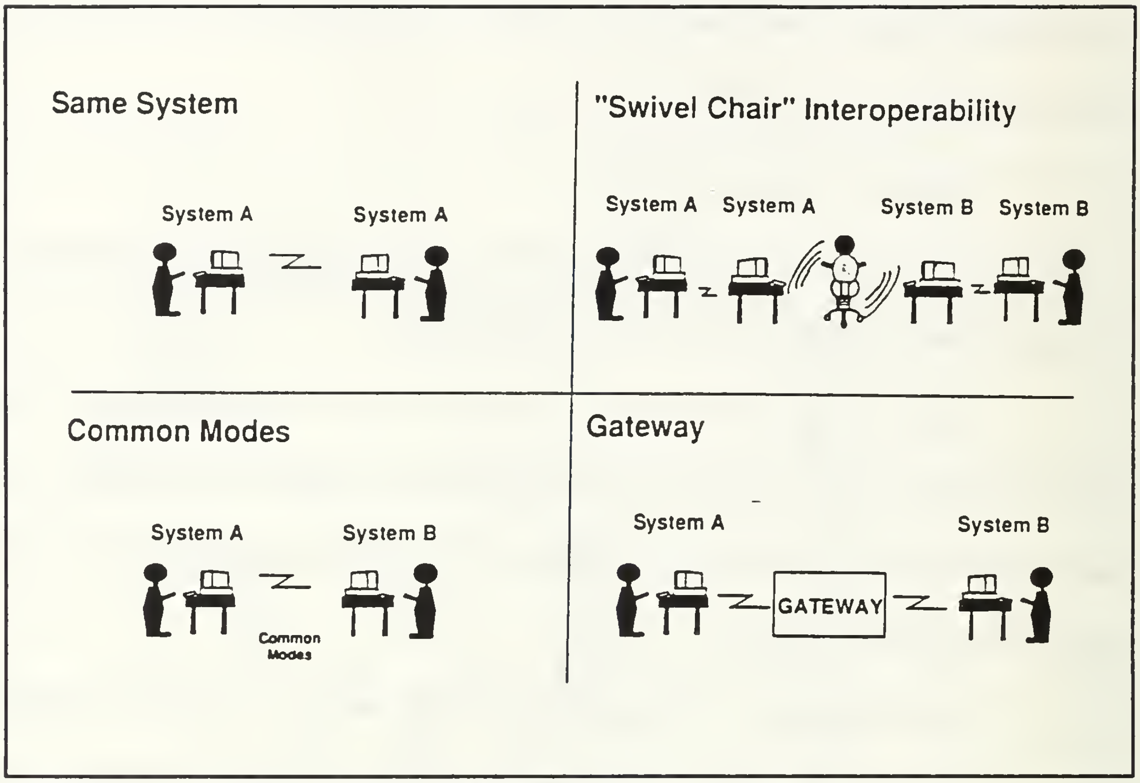

Figure 35: Methods of Interoperability [Source: Ref. 69]

a. "Swivel Chair" Interoperability

The "swivel chair" is nothing more than a human translator between two incompatible systems. Figure 35 shows a person receiving information on one system and sending it out on another [Ref. 71: 5]. This method is, as one can imagine, quite slow and prone to errors. However, it is inherently the most flexible. The individual only needs to know how to read information from one system and input the information into another system. The need for "swivel chair" interoperability can occur due to incompatibility in any one of the elements of interoperability. The "swivel chair" method puts a heavy burden on training, and personnel assets, and compounds configuration management problems. The "swivel chair" method was used in Operation Urgent Fury

and Golden Pheasant due to the incompatibility of the cryptographic devices to interoperate with all of the others. [Ref. 69:p 7]

b. Liaison Teams

Interoperability can be achieved through the use of liaison teams. Although not depicted in Figure 35, liaison teams are very similar in operation to the "swivel chair". Each system uses a human translator to put data into the proper format. The advantage of liaison teams is that there is someone to help interpret the data from the sending organization. There are many instances in which organizations must be able to exchange information rapidly and with great accuracy while possessing separate, independent systems that are not interoperable. This occurs when two forces must temporarily work together to achieve a common goal, such as in Operation Desert Storm. The Allied coalition in that operation was comprised of many countries, several of which had never conducted combined operations with many of the other forces present. Liaison teams were used to overcome many interoperability problems. Under these circumstances, liaison teams and their equipment are exchanged between organizations or forces, to allow the exchange of intelligible information, and to achieve at least a limited amount of interoperability. This allows each organization to coordinate with one of their "own" and have direct interface with the command element of the original organization.

The liaison team can greatly assist in the understanding of the capabilities and limitations of his forces. Generally, the richness of information provided by a liaison team far exceeds that of automated methods. Forces that have never worked together

before or were not intended to work together, generally require this high level of richness of information.

c. *Use of Common Modes*

Figure 35 shows two different systems interoperating. Even though the systems are different, they have achieved partial automated interoperability through agreement in the four necessary elements described earlier. Generally, this is "partial" interoperability with each system having some common modes with the other system. In this approach, it is common to have only a very austere interoperability capability. Both systems use compatible communications interface standards, message standards, operating procedures, and database and applications standards. This method requires increased testing to ensure interoperability. The training and configuration problems can also increase due to dissimilarities in the physical hardware and software. [Ref. 71:p 5]

d. *Use of a Gateway*

Two dissimilar systems can be made interoperational through the use of a gateway. This time there is an electronic translator that uses hardware and software to translate one system's information into a format that is understandable to the other. As with the "swivel chair" method, neither system needs to have all the elements in common with the other system. [Ref. 71:p 5]

Although faster and more accurate than the swivel chair, there are limitations to how much a gateway can do. Only certain standards can be translated, for example. From a training standpoint, the gateway would be transparent to the user, but

the system manager/maintainer would need increased training to handle the operation of the gateway. Configuration management may be easier depending on the capability of the gateway. The more capable the gateway and the more protocols and standards it call handle, the easier the configuration management due to the increased flexibility. [Ref. 72]

e. Use of the Same System

As shown in Figure 35, using the same system is a reliable method of achieving automated interoperability. Each system would have the same interface, message, operating, and data standards as the rest of the systems. The training would be the same for each user, and the configuration management would entail configuring only one system. [Ref. 71:p 5]

4. Steps to Achieving Interoperability

Figure 36 shows a pictorial representation of the basic steps to achieving automated interoperability. The steps put into action the elements of interoperability and demonstrate a sequence for minimizing problems. The feedback loops highlight the extensive amount of time and coordination that must take place. The steps include:

1. <u>Establishing System Requirements.</u> These requirements must be based on a mission perspective. These should be recorded in a Technical Interface Concepts Document.

2. <u>Develop and Specify Standards.</u> These include message, interface, and database/applications programs. These should be captured in a Technical Interface Design Plan.

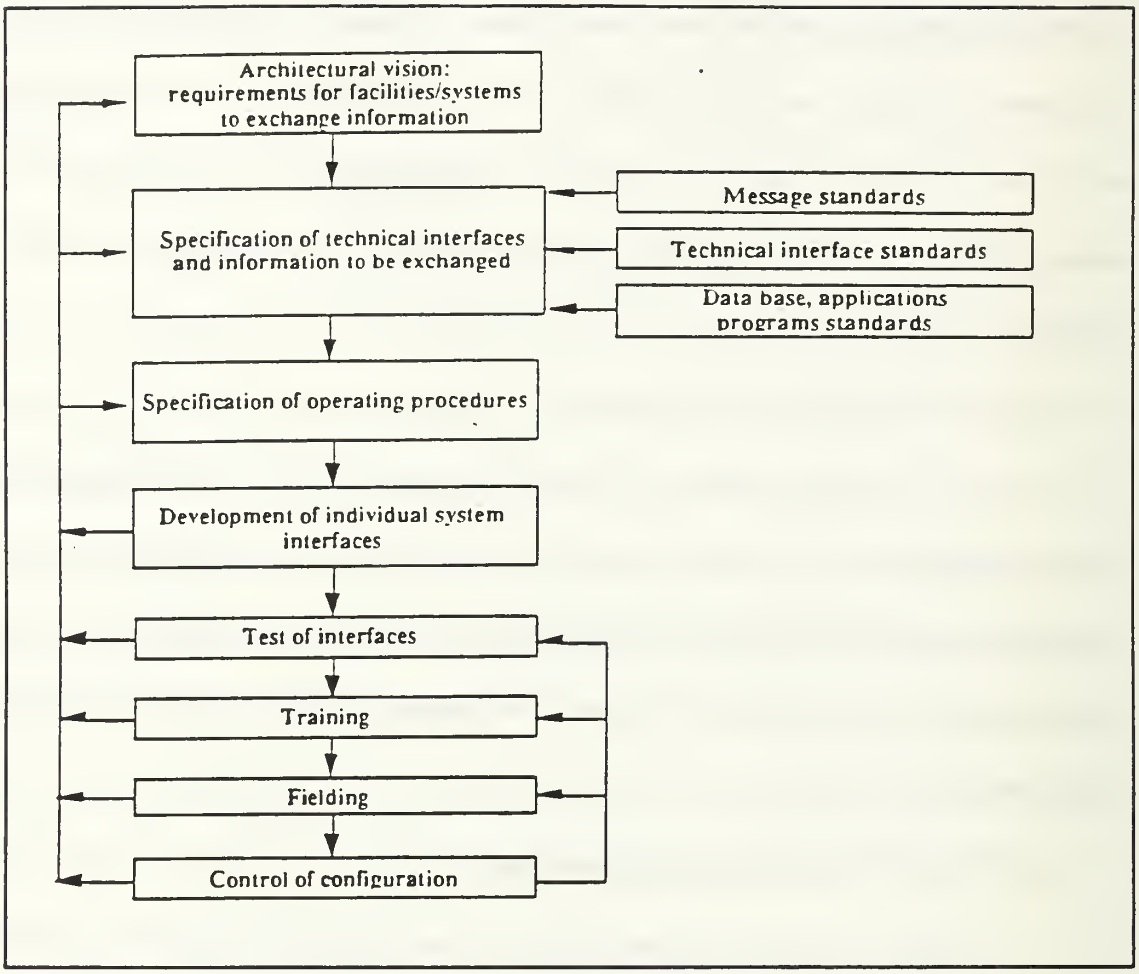

Figure 36: Steps to Interoperability [Source: Ref. 69]

3. Specification of Operating Procedures. These include the interface operating procedures, the establishment of data links, and methods of exchanging data.

4. Development of Interfaces. These are the individual system interfaces.

5. Test of Interface. This includes the development and implementation of an Interface Test Plan.

6. Training. This is the operational training of the operators to ensure their proficiency in establishing links and exchange of data.

7. Fielding.

8. Control of Configuration. This is managing and controlling the interfaces when the system becomes operational to ensure continued interoperability. [Ref. 69]

5. Benefits and Liabilities of Interoperability

Interoperability yields many benefits, but not without a price. A highly interoperable system suffers from liabilities as well. Both are discussed here.

a. Benefits

(1) Automated Interoperability. Many of the benefits are obvious. In particular, the minimization of errors in transmission and the increased speed of information processing and transmission are important benefits. There will be reductions in the amount of people necessary to perform "translation" services. Interoperable systems perform without the need for data to be massaged into new formats. Maintenance costs are reduced due to a limited amount of diversity in equipment. The equipment is all physically similar and/or operates in common modes. This reduces the amount of personnel, training, and spare parts required to maintain the system. [Ref. 69]

(2) Appropriate Methods of Interoperability. As noted above, there are some obvious benefits to automated interoperability. There are, as well, some not so obvious benefits of interoperability that transcend all interoperability methods. In general, interoperability leads to each unit having a relatively similar perception of the battle and the surrounding environment. This can lead to a stronger resistance to enemy actions. Friendly forces reap a synergistic benefit from working together without wasting effort or resources and can more easily reconfigure around a destroyed node or command center. [Ref. 69]

b. Liabilities

(1) Standardization Makes Things Easier for the Enemy. In his book, Technology and War, Martin Van Creveld took particular care to point out the liability of standardization:

> However desirable or necessary (standardization) may be from the point of view of efficiency, in war its result is to make things easy for the enemy. The amount of uncertainty with which he is confronted is diminished. He is put in a position where resources and attention can be focused on countering a single threat instead of many different ones. Finally, he is spared the dilemma of having to do two contradictory things at once; which probably represents the most important single way of using technology (or anything else) in order to obtain victory in war. [Ref. 68:p 319]

There are new vulnerabilities with automated, interoperable systems. In the past, a software virus was isolated to the few systems it could effect. Now, with automated, highly interoperable systems, viruses are compatible with all the systems and can create crippling disruptions in vast networks. [Ref. 71:p 6]

(2) Integration can Diminish the Capability of the System. Despite the fact that some systems can achieve "state of the art" levels of speed and efficiency, they must often conform to interoperability standards which direct a less efficient method of operation [Ref. 71]. These operability standards usually derive from older, outdated systems that, with today's technological pace, are nearing obsolescence. Although this practice may be more cost effective in the short term, it is only marginally effective in the long run. [Ref. 39]

> When new systems are required to run in a mode that emulates outdated equipment, increased performance benefits of the newer system are sacrificed. These benefits

that are sacrificed are often the justifications for procuring the system in the first place. [Ref. 39:p 48]

A current example of this liability involves the Single Channel Ground Air Radio System (SINCGARS). SINCGARS is a single channel, frequency hopping VHF radio designed to be resistant to jamming. However, in order to operate with the older PRC-77 and VRC-12 VHF radios, it must often suspend its frequency hopping capability and operate on a single frequency.

(3) Interoperability Costs More. Interoperability requires increased coordination. This requires more man hours which leads to higher costs. These man hours result from increased effort in configuration management and from the limitations placed on the size, weight, and power of the equipment to be built. Another cost in achieving interoperability is attaining backward compatibility. Backward Compatibility entails enabling the system to be interoperable with older, fielded systems. Interoperability can be achieved through any suitable method, and need not be restricted to technological changes. These older systems usually utilize outdated technology, behind that being fielded in the new system. It can become cost prohibitive to design the system in development to both comply with older operational standards and interfaces and achieve "state of the art" capability as well. This tends to restrict the full utilization of "state of the art" technology. [Ref. 71]

C. INTEROPERABILITY ASSESSMENT

1. Findings of the Naval Research Advisory Committee

The Naval Research Advisory Committee (NRAC) published a report shortly after the demise of MIFASS. The report examined the intra/interoperability capabilities of the Marine Corps. They found that many interoperability deficiencies existed, primarily due to a lack of strong, central coordination. This led to many configuration management problems with MTACCS and its associated subsystems. The tactical data interfaces were inadequately defined or satisfied. As stated earlier, this led to problems with basic interoperability between MIFASS and the message switch that was to handle MIFASS' message traffic. The documentation was reactive instead of directive and was not internally consistent. Standards were not enforced uniformly and waivers were the rule instead of the exception. [Ref. 8,43]

The committee also stated that the crucial performance standard of a C^2 system was its level of interoperability [Ref. 43]. A C^2 system that can not interoperate, commands and controls very little and receives little outside information. The committee proposed recommendations for improvements in three areas. Those recommendations are outlined here:

a. Systems Engineering

The system baseline should be based on an open architecture with standard interfaces. This will allow developers and designers to "plug in" their projects and will force a set of standards. System engineers must concentrate on what is

achievable in the near term and incrementally enhance the system, aiming for maximum integration of tactical data systems, automated information systems, and tactical communications systems. [Ref. 43:p 4]

b. Management

A strong, centralized intra/interoperability configuration management authority should be established with unambiguous responsibility for all tactical data and communications systems. Baseline documents should be transformed into authoritative guides. These documents should be regularly reviewed and updated to incorporate new technology and maintain internal consistency. [Ref. 43:p 5]

Management continuity is a problem that can be solved through career planning and development for Marine Corps officers. This coupled with long term technical support for program managers should enhance configuration management and minimize the changes to requirements. [Ref. 43:p 5]

c. Implementing Strategy

The Committee stated that near term efforts should concentrate on documentation updates, implementing FIREMAN[35], and planning for enhanced tactical communications. The implementation of FIREMAN should be treated as part of a larger C^2 systems, and not just a separate entity. It should be acquired through an evolutionary strategy using off-the-shelf equipment and software. Command and control data requirements should be re-evaluated for all phases of MAGTF operations. All critical

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[35] FIREMAN has developed into the Tactical Combat Operations (TCO) system.

design constraints (such as data security/integrity and system robustness) must be defined. An overall architecture should be adopted which satisfies near term needs and supports future growth. [Ref. 43:p 5]

2. Current Marine Corps Efforts to Enhance Interoperability

> The timely, accurate, efficient, and secure flow of vital processed and tailored information is the key to removing the uncertainty associated with the chaos of war. [Ref. 73:p 81] ... technology alone is not the total solution. It is absolutely essential that standards be developed and adhered to by all members of the joint and combined community, so that our technologically advanced equipment can interoperate effectively to collect, process, and disseminate the flood of information that currently threatens to inundate the commander. [Ref. 73:p 83]

The current efforts of the Marine Corps to enhance interoperability are threefold.

a. Organizational efforts

In an effort to highlight interoperability requirements, General Alfred M. Gray has reorganized the offices responsible for interoperability in the Marine Corps. In Signal magazine, General Gray wrote:

> The Headquarters, U.S. Marine Corps, has been reorganized to merge the Intelligence and Command, Control, Communications, and Computers (C^4) divisions into the Command, Control, Communications, Computers, Intelligence, and Interoperability (C^4I^2) Department. This step has, for the first time, given formal cross-discipline visibility in the complementary fields of C^4 and intelligence. With the addition of the second "I" for interoperability, that concern so critical to C^2 systems has been elevated to the position of importance that it deserves. [Ref. 73:p 82]

This reorganization has consolidated the interoperability focus to facilitate the coordination and distribution of standards, yet has maintained the focus in three key

areas of systems development and acquisition. Currently, there are three organizations responsible for ensuring intra/interoperability:

1. C^4I^2 Section at HQMC - Responsible for establishing policies and procedures for assuring intra/interoperability of all Marine Corps systems.

2. MCCDC - Responsible for defining, validating, and publishing intra/interoperability requirements.

3. MCRDAC - Responsible for cataloging, developing, and describing approved Marine Corps intra/interoperability standards for messages, data elements, and communications protocols. [Ref. 74]

The relationships between these sections are depicted in Figure 37. The reorganization should aid in the establishment of a central configuration manager (MCRDAC), with clearly defined responsibilities as suggested by the Naval Research Advisory Committee.

There are two interoperability organizations that are used to aid in establishing policy, requirements, and standards. The first is the Interoperability Planning Board (IPB), chaired by the Commanding General, C^4I^2 HQMC. This board develops recommendations for interoperability policy; soliciting responses from the other organizations as shown in Figure 37. This board also controls the issuance of temporary waivers, weighing the impact of the waivers on other Marine Corps systems. The second key organization is the Interoperability Configuration Control Board (ICCB). This board is chaired by the Commanding General, MCRDAC and makes recommendations to MCCDC for changes to interoperability requirements and to MCRDAC for changes to interoperability standards. These recommendations are based on input from the Fleet

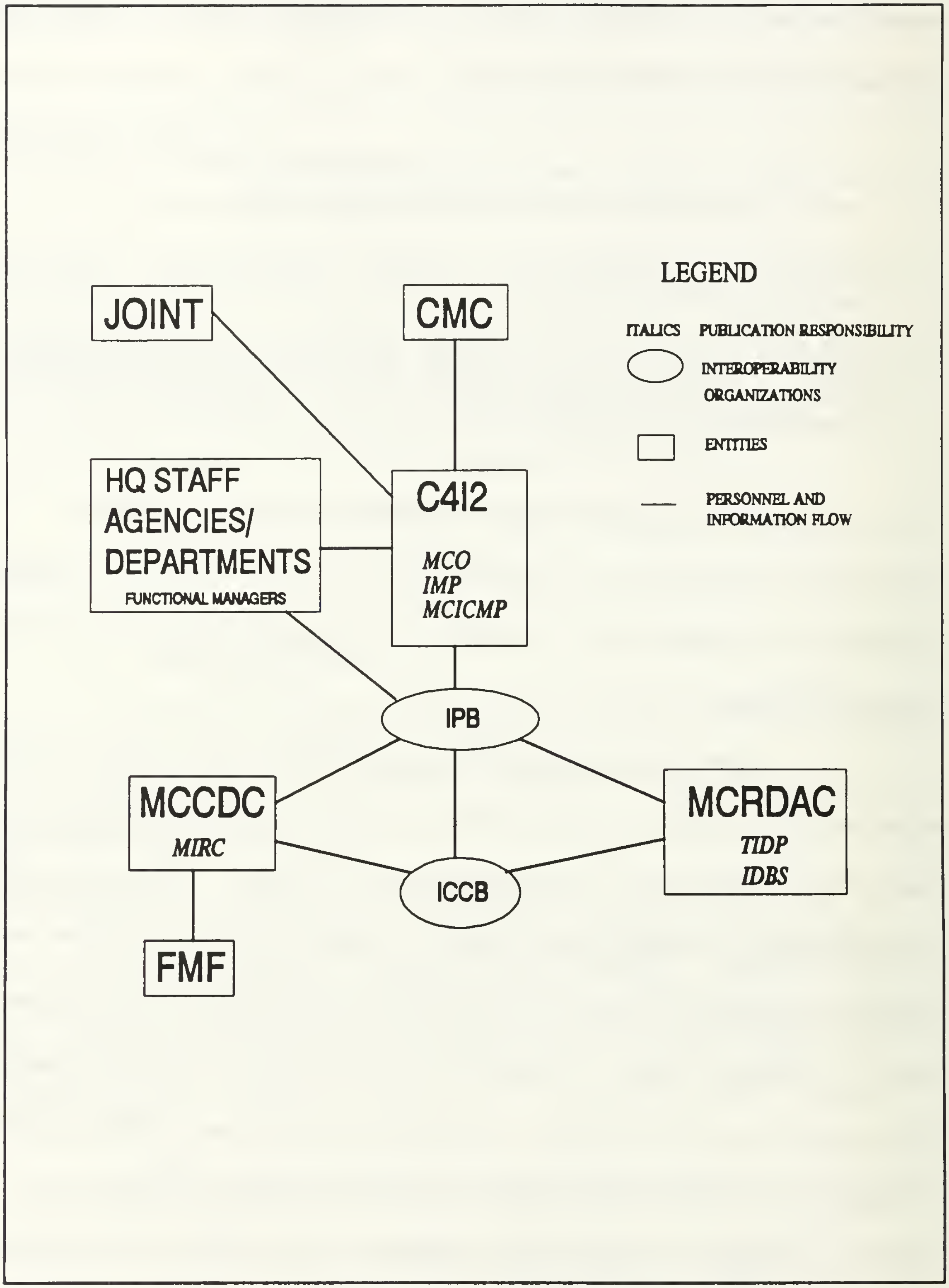

Figure 37: Intra/Interoperability Relationships [Source: Ref. 74]

Marine Force and the other interoperability organizations depicted in Figure 37. Through the use of these boards, the interoperability cross coordination problem between programs that plagued MIFASS should be avoided in MTACCS. [Ref. 74]

b. Administrative efforts

There are a number of documents that delineate interoperability guidance:

1. MCO 3093.1. This order establishes policies and management procedures within the Marine Corps to ensure that both Marine Corps intraoperability and joint/combined interoperability standards are implemented in Marine Corps tactical C^4I^2 systems. This order is published by the Assistant Chief of Staff for Command, Control, Communications, Computers, Intelligence, and Interoperability. [Ref. 74:p 1-3]

2. Interoperability Management Plan (IMP). This plan is written to ensure the exchange of critical tactical information in Marine Corps combat operations through interoperability management. Its aim is to facilitate the implementation, verification, and testing of standards on developing tactical data systems, prescribing coordination between various configuration management bodies, and to ensure interoperability requirements are adequately planned for and properly funded. The plan is published by the Assistant Chief of Staff for Command, Control, Communications, Computers, Intelligence, and Interoperability. [Ref. 75:p 1-3]

3. Marine Corps Interoperability Configuration Management Plan (MCICMP). This plan addresses current requirements for configuration management and interoperability requirements and for message, data, and protocol standards. This plan is published by the Assistant Chief of Staff for Command, Control, Communications, Computers, Intelligence, and Interoperability. [Ref. 75:p 1-5]

4. MAGTF Interoperability Requirements Concept (MIRC). The purpose of this document is to assist in meeting interoperability objectives by identifying and documenting interoperability requirements that have been established in doctrine. Additionally, this document is to provide an interoperability requirements baseline for the development of standards contained in the Technical Interface Design Plan (TIDP), and to validate input into joint C^3 architectures. This plan is published by the Commanding General, Marine Corps Combat Development Command. [Ref. 76:p 1-3]

5. Technical Interface Design Plan (TIDP). This document provides approved Marine Corps intraoperability standards including message, data element, and protocol standards. The TIDP provides information on each tactical data system's or interconnecting equipment's interface description by outlining approved message, data, and protocol specifications including those that temporarily deviate from the standard through approved waivers. This document is published by the Commanding General, Marine Corps Research, Development, and Acquisition Command. [Ref. 77:p 1-3]

6. Interoperability Data Base System (IDBS). The IDBS maintains MIRC interoperability requirements and supports the interoperability program and configuration management of interoperability requirements and standards. [Ref. 74]

The steps to interoperability specifically state that a Technical Interface Concept Document and a Technical Interface Design Plan be written to aid interoperability. As noted above, the Marine Corps complies with these recommendations. The steps also list a configuration management plan. The Marine Corps has written an Interoperability Management Plan and an Interoperability Configuration Management Plan. The updating and rewriting of Marine Corps Interoperability documents is a step toward fulfilling Naval Research Advisory Committee recommendations to redo the documentation. NRAC stated that the documents in 1987 were reactive and not directive. An evaluation of the rewritten documents was not an objective of this thesis. However, the increased visibility of these documents demonstrates a general trend towards increased interoperability awareness.

c. *Technical efforts*

From a technical aspect, the Marine Corps is working towards increasing use of industry standards. This will allow common, tested interfaces, operating systems,

and hardware. In closely watching the development of other service C^3 systems, the Marine Corps is kept abreast of what it will take to maintain interoperability. [Ref. 34:p 4.3]

3. Assessment of MTACCS Efforts to Enhance Interoperability

a. Introduction

This section discusses the current efforts, for which documentation was available, in MTACCS and how they measure up to recommendations that have been stated concerning the proper way to ensure interoperability.

b. MTACCS Interoperability Elements

(1) Technical Interface Standards. As stated in a report commissioned of the Pacific Northwest Laboratories, MTACCS will employ industry standards for communications and storage interfaces and will use NDI common buses for peripheral compatibility [Ref. 34:p 4.3]. Repeatedly stated throughout MTACCS documentation, is the concept of common hardware and common software [Ref. 2:p 1-5]. The common hardware and software must meet the standard interfaces set forth in the Technical Interface Design Plan (TIDP), or in order to maintain consistency, the standards must change to keep pace with technology. This will save in redesigning new standards and provide industry an opportunity to start designing and building using standards with which they are familiar. This will allow the employment of a wider array of Commercial-off-the-Shelf items and will greatly enhance interoperability due to the great proliferation of similar computers throughout the military around the world. The system is to be built

around an open architecture using a modular concept. This will facilitate the upgradability of the system, and should be readily attainable through the use of predefined hardware and software interfaces.

(2) Message Standards. Message standards have been published in the Technical Interface Design Plan (TIDP) However, Pacific Northwest Laboratories has stated that these are incomplete for use across all MTACCS functional areas and cautions against progressing past FDS 1, until there has been a proper integration of applicable Marine Tactical System (MTS) messages [Ref. 34:p 4.33]. The use of the POSIX[36] for system support software does allow for a limited variety of message formats [Ref. 34:p 4.9]. The program managers and prime contractors of MTACCS subsystems were interviewed concerning the impact MTACCS would have on their system. A large part of the discussion centered on the impact of connectivity, namely the message formats and operating systems. The visibility of this problem is one positive step in the correct direction. [Ref. 34:p 4.1]

(3) Operating Procedures. At this point in time, specific operating procedures have not been defined. As stated later in this section, MTACCS is currently in step two, specification of interfaces and information, of the steps to interoperability. This step must be completed before step three, specification of operating procedures.

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[36] A standardized open system computer operating environment based on UNIX.

(4) Database and Program Applications Standards. At this point in time, the Marine Corps has decided there would be common software and common applications programs. This lends itself to interoperability, at least within the Marine Corps, by the use of the same systems. The Marine Corps is currently investigating Database Management Systems (DBMS) and has not yet set a standard. [Ref. 34:p 4.20]

c. MTACCS Level of Interoperability

(1) Current. Currently, the Marine Corps has made great strides through Operation Desert Storm. Many communications problems have been, at least temporarily, ironed out through the use of borrowed or reconfigured equipment. The aviation element of the Marine Corps has been interoperable for many years, not in every system, but in the overall scheme. Useable information in the proper format is passed to other services and foreign militaries. In examining the levels of interoperability, the majority of the Marine Corps would fall in the "swivel chair" or liaison team category of interoperability. A Marine would physically transfer the information from one system to the other, be it a manual or automated system, or explain a situation and transfer information to another organization. As stated above, much of the aviation element of the Marine Corps interoperates in the common mode. Different systems with common methods of transferring data.

(2) Anticipated. The intent in integrating MTACCS with fully developed and/or fielded systems is to only integrate them to the extent possible without causing major revisions to their elements [Ref. 32:p 17]. This infers that major systems

that are to be fielded will only make minor changes, initially to enhance interoperability. Long term interoperability standards will be developed, but compliance with those standards will be achieved in an evolutionary manner. There will be limited forced interoperability at first, and then through the evolutionary development of MTACCS and the product improvements of its subsystems, MTACCS will achieve a greater measure of interoperability in time. It is envisioned that a "swivel chair" interoperability will be attained with systems currently developed. Systems in development should be able to attain some common modes of operation. Gateways will be developed to increase interoperability until systems life cycles progress in that their interoperability is upgraded through product improvement. Through these product improvements, MTACCS will achieve, in an evolutionary manner, full integrated interoperability. Interoperability with other services would be achieved through common modes of operation and gateways. Pacific Northwest Laboratories has been examining the functioning of the Army ATCCS and CASS programs as a reference for MTACCS. [Ref. 34:p ii]

d. MTACCS Steps to Interoperability

Currently the MTACCS program appears to be in the second step of specifying the technical interfaces and the information to be exchanged [Ref. 34]. The first step was accomplished in the original MTACCS concept stated in the late 1960's and redone in the revitalization of the late 1980's.

e. Avoidance of Historical Problem Areas

(1) Management. As stated in MCO 3093.1C, only one agency has the responsibility for setting and maintaining standards, MCRDAC. The others, C^4I^2 and MCCDC, identify problems, requirements, and set policy. The directives more clearly delineate standards and responsibility, although they apparently could be better, they are a step in the correct direction [Ref. 34]. At MCRDAC, an office responsible for disciplining the development of systems in accordance with set standards was established to ensure configuration management [Ref. 34:p A.33]. The last historical problem is that of proper priority. Interoperability has been a key buzzword for many years and is enjoying a lot of popularity. It is difficult to assess if this is enough to make an impact.

(2) Architectural. MTACCS is defined as having an open architecture. It is being built in software modules on common operating systems. Common types of hardware are being used on which to operate the system. [Ref. 34] This should ease configuration changes and upgrades to the system. This should also enhance interoperability through the use of modules.

(3) Standards. A key guideline for MTACCS has been to establish standards early. An early definition of standards can prevent a profusion of incompatible "standards. Early MTACCS subsystems, such as MIFASS, developed unique interfaces in the absence of an enforced common standard. The result was the incompatibility of MIFASS with other MTACCS systems. Pacific Northwest Laboratories has reinforced the concept of early standard development throughout their study. [Ref. 34] As stated

before, the Marine Corps has rewritten a number of its intra/interoperability standards documents and continues to examine solutions for undefined standards.

(4) Systems. Backward compatibility could be an extensive problem. Pacific Northwest Laboratories has examined the problems of interfacing with established systems [Ref. 34]. While backward compatibility can be achieved by an interoperability method, a technological solutions appear to be the method of choice. Technological problems are beyond the scope of this thesis. However, a high priority must be given to backward compatibility, or the older, incompatible systems must be eliminated.

D. CONCLUSIONS

> History is filled with examples of vastly superior forces failing to prevail or suffering actual defeat at the hands of dramatically weaker forces that possessed more flexible, responsive and effective C^2 ... our intention is to ensure that our C^2 systems foster sound tactical decisions that will enable commanders to focus their tremendous combat power at the enemy's center of gravity. [Ref. 73:p 83]

MTACCS should not significantly change operationally, the way Marines fight. It will provide more processed and useable information to the commander and reduce his processing time. Neither tactics, strategy, nor procedures are scheduled to change. [Ref. 27] Interoperability will be achieved by establishing standards and complying with these standards in an evolutionary manner. As MTACCS evolves, the various subsystem will progress through several levels or methods of interoperability. A subsystem may utilize liaison teams at first, then progress to a common mode or gateway, and eventually achieve full integration. It is envisioned that as the system is used, more efficient and effective methods of operation will be discovered. As each service gains experience and

shares the knowledge gained, higher levels of interoperability will be achieved. As demonstrated in Operation Desert Storm, the U.S. Military will be fighting in a arena with not just the other services, or NATO allies, but with a significant portion of the world. A computer terminal with translation, electronic mapping, and message handling capability can greatly enhance the power focused at the enemy's critical mass and is much more efficient than a liaison team. While more efficient, automated systems are not necessarily more effective. In actuality, liaison teams can not be completely replaced by automated systems. Liaison teams provide a richness of information not found in automated systems.

VIII. CONCLUSIONS

A. SUMMARY

1. Purpose of the Assessment

The driving goal of this assessment is to develop an understanding of the strengths and the possible risks inherent in the new MTACCS concept. Additionally, recommendations are proposed that offer methods of mitigating the impact of identified risk factors.

2. A Challenging Task

A quarter of a century has passed since the inception of MTACCS. Tens of thousands of man years have been invested in its development. Assessment of a project of this scope is an enormous challenge. The authors have expended considerable effort simply in attempting to develop a thorough understanding of the many complex issues involved.

3. Limitations of the Assessment

The scope of this assessment is very broad. Emphasis on any one subject has been necessarily limited. Many of the guiding directives and planning documents are written only in draft or are not yet written at all. Additionally, the MTACCS program is dynamic and evolving. Some concept decisions are being made even as this assessment is being written. All of these factors place limitations on the credibility of the

assessment. Much of the information contained in the assessment, however, remains current. The conclusions are intended to be general and do not address a fine level of detail. A finer level of detail is beyond the scope of this effort due to the limitations that have been discussed.

4. Methodology

An assessment of a command and control system may examine many factors. Assessments typically examine program management procedures, cost-effectiveness, performance, etc. In the case of MTACCS, the failure of the key MTACCS subsystem, known as the Marine Integrated Fire and Air Support System (MIFASS), was viewed as a principle driver of the "revitalized" concept. A thorough investigation of the MIFASS program revealed several key ares of concern. Important among these were the basic feasibility of the project, cost-effectiveness, combat development practices, and interoperability. This assessment then attempts to determine the likelihood of the "revitalized" MTACCS experiencing problems in the same areas.

This assessment began with an investigation of a key MTACCS subsystem. MIFASS had crippling acquisition and system engineering problems and the project was canceled in 1987 after almost twenty years in development. Chapter II detailed the difficulties encountered during the MIFASS program and discussed the causes of the MIFASS failure.

After the termination of MIFASS, the MTACCS program was re-evaluated and a "revitalized" concept was published. Chapter III described the MTACCS concept as it is currently envisioned. Many of the guiding directives and strategy documents that

define MTACCS, however, are still in draft. While the basic thrust of the new concept is stable, some changes in concept definition are occurring even as this thesis is being written.

The implementation of MTACCS is an extreme challenge. At least several of the objectives of MTACCS fall into the "high risk" category and may not even be possible to achieve at any reasonable cost and expenditure of effort. The assessment in Chapter IV was an evaluation of the feasibility of the MTACCS goals.

It is often tacitly accepted that the automation of a particular task has inherent benefits that always result in improved combat effectiveness. Chapter V addressed the potential cost-effectiveness of MTACCS. The cost of MTACCS was related to its ability to increase effectiveness to determine if spending funds on MTACCS is an optimal use of resources.

In Chapter VI, the Marine Corps' Combat Development practices were reviewed to determine the impact of combat development on MTACCS.

Chapter VII provided an assessment of the interoperability efforts of MTACCS and the levels of interoperability expected to be achieved.

B. CONCLUSIONS

1. MIFASS

a. Key Problems

There were four key problems within the MIFASS program:

1. A lack of consensus concerning the doctrinal issue of centralization versus decentralization.

2. Unstable requirements definition that failed to state requirements in mission terms.

3. Underestimation of the complexity of the task.

4. Adherence to the traditional approach of concentration on hardware first and then the software.

The clumsy and inefficient management system was a hindrance to the program, ***but the only devastating problem was the lack of the foundation necessary to establish the program in the first place: sound initial requirements definition based on appropriate doctrine.***

b. The Impact of MIFASS on MTACCS

In response to both the Goldwater-Nichols Reorganization Act of 1986, and the termination of MIFASS in 1987, the procurement business in the Marine Corps has been radically changed. The old matrix organization has been replaced with a dramatically different acquisition system.

It is unlikely that future Marine Corps efforts will try the "big system approach" with simultaneous development of several elements of the Marine Corps in one

big step[37]. Wary of falling into that trap again, current Marine Corps philosophy embraces the ideas of modular, evolutionary acquisition using non-developmental items as much as possible. The "build a little, test a little, field a little" approach will be used to prevent another MIFASS from happening. Avoiding the "big system approach", however, may result in a reliance on simple, basic solutions that trade away efficiency and effectiveness for simplicity.

Only one aspect of the "big system approach" need be avoided. The Marine Corps should not attempt to develop a major system such as MTACCS in one big step. An evolutionary development is the preferred method. The second aspect of the "big system approach", however, remains a legitimate requirement. Integrated solutions that address all elements of the Marine Corps system are necessary to maximize combat effectiveness within resource constraints.

2. The New MTACCS Concept

a. General

The new MTACCS concept properly anticipates the need for an automated command and control system to support MAGTF operations. Automation of command and control tasks has the potential of significantly increasing the combat effectiveness of Marine forces.

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[37] The "big system approach"basically entails simultaneous development of elements such as doctrine, force structures, and equipment and an emphasis on achieving an acceptable system in one iteration.

b. Feasibility

The MTACCS concept is feasible. The use of an Evolutionary Acquisition strategy markedly strengthens the program. In an evolutionary, incremental development, advances in technology can be more readily introduced as upgrades to the core system. There are several factors, however, that can undermine the basic feasibility of the project. These factors must be addressed and mitigated to ensure they do not inhibit development.

(1) Use of Data Communications. The MTACCS program must ensure that informal communications and voice radio are not entirely supplanted by data communications. To rely too heavily on data transmissions violates the spirit of Marine Corps doctrine and runs the risk, as Van Creveld said, of "reducing command to trivia" [Ref. 41:p 273].

(2) Centralization. A clear vision of the degree of centralization of command and control must be established early and maintained. In addition, it is vital that the degree of centralization be strongly supported across the entire Marine Corps. There must be consensus. Division on this highly critical issue can cripple the program.

(3) Communications Capacity. The simultaneous development of both MTACCS and its supporting communications system is a hauntingly familiar scenario. The MIFASS system was also intended to operate with communications equipment that was being developed concurrently. The communications capacity was inadequate then and it appears that the capacity remains inadequate despite the fielding of new equipment.

(4) Multi-level Security. There is a need to allow users of differing security levels to be able to access the same system using the same database. Until this can be done with a high degree of confidence, our intelligence sources could quite possibly be in jeopardy. Our intelligence system could be unintentionally violated. Fortunately, there appears to be a strong interest displayed, by both industry and the services, in the development of multi-level security for both military and commercial applications. It appears that the Marine Corps need only follow those developments closely and evaluate candidate methods to determine the method most appropriate for Marine Corps needs.

(5) Software development. The MTACCS development team has laid out a development plan that incorporates all of the current "best advice". Adherence to this advice will certainly promote success. The challenge remains significant, however. Furthermore, the decision to maintain current doctrine and force structure without modification eliminates potential sources of mitigation of software complexity. It is possible, for example, that changes to doctrine could reduce the software burden.

c. Cost-Effectiveness

Automation of command and control functions has the potential to significantly enhance the combat effectiveness of the Marine Corps. The proper level of automation, however, may not be "all you can get". The most cost effective level of automation may be that which restricts automation to the higher headquarters; regiments and above. The value of automation at the lower echelons (battalion and below) can be

relatively small. Generally, this is because the burden of additional equipment and training requirements can outweigh the increased performance gained through automation. Additionally, many C^2 tasks at lower levels do not lend themselves to automation. [Ref. 58:p 11]

Based on the results of the TCO study, automation of command and control tasks at the battalion level and below may not be the most cost-effective method of increasing combat effectiveness. The implication of this study is clear. Cost-effective automation of C^2 tasks at battalion level and below requires lightweight, easy to use equipment that addresses only those tasks that require automation.

d. Combat Development

(1) Trends in the Development of Command and Control Systems. Currently, there appears to be four general trends in the development of C^2 systems. The first is an emphasis on equipment or materiel solutions. MTACCS appears to follow this trend. The MTACCS Master Acquisition Plan states that current command and control tasks will be automated (new equipment) but no changes will be made to force structure, doctrine, etc.

The second trend is a reliance on basic solutions that addresses only one element of a complex system. MTACCS, for example, addresses primarily materiel. Other elements of the Marine Corps "system" will not be modified.

The third trend is the use of an "applique approach" for command and control systems. Force structure, doctrine, and procedures are defined first and the C^2 system is applied as an applique. Here, too, MTACCS appears to follow the trend.

The last trend is the increasing emphasis of standardization over optimization. Merely coping with technology is consuming a majority of our efforts. Optimizing appears to be a lesser concern. MTACCS may well be following this trend as well. Only small, incremental improvements to automation are expected. Gradually, these incremental improvements will achieve a desired level of automation. The majority of emphasis, however, appears to be in achieving a working system rather than optimizing effectiveness.

(2) Little Faith in the "Big System Approach". As mentioned previously, the failure of MIFASS has caused the Marine Corps to have little faith in the "big system approach." This is unfortunate because it appears that the chosen alternative is a tendency to develop only one element of the system at a time: change some equipment, for example, and keep all other system elements relatively static. While this method is less complex, it trades a great deal of effectiveness away to achieve that lower level of complexity. Regardless of the bad experience of MIFASS, there remains a need to implement change in a manner that integrates all of the elements of the system.

The reduction of complexity through the use of an evolutionary development scheme is highly desirable. Attempting to further reduce complexity by addressing only equipment, for example, may be sacrificing too much effectiveness for the sake of simplicity. Standardization is emphasized more than optimization. The

integrated development of all elements of the Marine Corps "system" in an evolutionary manner has the potential of promoting both optimization and standardization.

(3) The Need for Systems Engineering in the Marine Corps. In recent years, revolutionary advances have occurred most often in the development of weapons and equipment. Users and developers alike are tempted to solve most deficiencies with new technology. The MTACCS program is following a similar approach. Basically, only equipment will be changed. Force structure and doctrine will remain unaltered.

New technology alone, however, focuses on only one element of a complex system. While technology is capable of marvelous achievements, it continues to be only a part of a larger system. Equal attention must be given to all elements of the system to ensure optimal use of resources. Modifications to doctrine, procedures, or force structure, for example, may better complement a major advance in C^2 technology than the current doctrine or procedures.

Adherence to a systems engineering process in combat development has the potential of mitigating the current trends and restoring the oft neglected elements of the system to their proper levels of emphasis. Through trade-off studies, for example, appropriate doctrine, level of personnel, and types of equipment can be carefully chosen to optimize effectiveness within resource constraints.

e. Interoperability

It is important to note that 100% automated interoperability is neither necessary nor desired. Some method of interoperability must be utilized but that need not

entail an automated capability. In the case of MTACCS, interoperability will be achieved by establishing standards and complying with those standards in an evolutionary manner. It is envisioned that as the system is used, more efficient and effective methods of operation will be discovered. As MTACCS evolves, the various subsystems will progress through several levels or methods of interoperability. A system may utilize liaison teams at first, then progress to a common mode or gateway, for example. Automated interoperability of all C^2 systems in the long term is a principle goal of the MTACCS concept. Computer terminals with translation, electronic mapping, and message handling capability can greatly enhance the power focused at the enemy's critical mass and are more efficient than liaison teams, for example. Liaison teams, however, will never be entirely supplanted by automated methods. Liaison teams provide a richness of information to the supported unit that is generally impossible to achieve through automation alone.

C. RECOMMENDATIONS

The conclusions that have been expressed in this chapter indicate that the development of MTACCS remains a significant challenge. Several risk factors have the potential of seriously impeding the progress of MTACCS. Mitigation of these risk factors is not an easy task. The following recommendations offer potential opportunities for lessening the developmental risk inherent in the MTACCS programs and increasing combat effectiveness.

1. Sufficient voice channels must be maintained in the MTACCS system to support the concept of "implicit communications" because we communicate in <u>how</u> we talk; in our inflection and our tone of voice.

2. The developers of MTACCS recognize that the communications capacity of current and near term Marine Corps equipment will quite probably be exceeded by MTACCS. A determination of the anticipated communications capacity need is difficult without a firm understanding of the specific information exchange requirements of MTACCS which have yet to be developed. Regardless, the communications capacity requirement for MTACCS must be determined quickly to allow for timely development of a solution to the problem.

3. Continued emphasis must be placed on establishing multi-level security if TCO is to interface with IAS and provide unit commanders with real time intelligence. Without a demonstrated secure, trusted system, there will be little user support for allowing classified information of a sensitive nature to be passed on MTACCS nets.

4. The lack of faith in a "big system approach" should not be permitted to cause a complete departure from integrated solutions. Some effort should be made to permit the concurrent evolution of doctrine, force structure, and procedures as well as material. Instituting the FASC concept along with current MTACCS objective, for example, may offer still greater effectiveness. Evolutionary development would remain the method of choice. The solution being developed would certainly be more complex. A total reliance on basic solutions should be avoided. Attempts to break a complex problem down into basic, manageable pieces have, in the past, resulted in many of the pieces being solved independently. This can lead to disjoint solutions that do not maximize combat effectiveness within the imposed resource constraints.

APPENDIX A: GLOSSARY

AAW	Antiair Warfare
ACAT	Acquisition Category
ACE	Aviation Combat Element
ACG	Acquisition Coordinating Group
ACMC	Assistant Commandant of the Marine Corps
ADM	Acquisition Decision Memorandum
ADPE-FMF	Automatic Data Processing Equipment - Fleet Marine Force
AE	Acquisition Executive
AEP	Adaptability Evaluation Program
AFATDS	Advanced Field Artillery Tactical Data System
AIC	Automated Information Center
AOA	Amphibious Operational Area
APO	Acquisition Project Officer
APS	Acquisition Program Sponsor
ARC	Atlantic Research Corporation
ASP	Acquisition Strategy Plan
ASPO	Acquisition Sponsor Project Officer
ATACC	Advanced Tactical Air Command Central
ATCCS	Army Tactical Command and Control System
ATDL-1	Army Tactical Data Link-1
ATO	Air Tasking Order
C^2	Command and Control
C^3	Command, Control, and Communications
C^3I	Command, Control, Communications, and Intelligence
C^4I	Command, Control, Communications, Computers, and Intelligence
C^4I^2	Command, Control, Communications, Computers, Intelligence, and Interoperability
CATF	Commander Amphibious Task Force
CBRS	Concept Based Requirements System
CECOM	U.S. Army Communications-Electronics Command
CIT	Counter Intelligence Team
CLF	Commander Landing Force
CMC	Commandant of the Marine Corps

CNA	Center for Naval Analyses
COC	Combat Operations Center
Comm	Communications
COTS	Commercial-Off-The-Shelf
CSI	Command Systems Incorporated
CSS	Combat Service Support
CSSCS	Combat Service Support Control System
DASC	Direct Air Support Center
DBMS	Database Management System
DC	Development Coordinator
DCS	Defense Communications System
DC/S	Deputy Chief of Staff
DCT	Digital Communications Terminal
DirDevCtr	Director of the Development Center
DOD	Department of Defense
DPM	Deputy Program Manager
DPO	Development Project Officer
ECM	Electronic Counter Measures
EDM	Engineering Development Model
EW	Electronic Warfare
FASC	Fire and Air Support Center
FDC	Fire Direction Center
FDS	Field Development System
FIREFLEX	Marine Corps Flexible Fire Support System
FIREMAN	Marine Corps Fire and Maneuver System
FMF	Fleet Marine Force
FSCC	Fire Support Coordination Center
GAO	General Accounting Office
GCE	Ground Combat Element
GOR	General Operational Requirement
GPS	Global Positioning System
HQMC	Headquarters Marine Corps
HR	Helicopter Request
IAC	Intelligence Analysis Center
IAS	Intelligence Analysis System
IDA	Institute for Defense Analysis
IDASC	Improved Direct Air Support Center
IFASC	Improved Force Automated Services Center

IDBS	Interoperability Database System
IIF	Imagery Interpretation Facility
ILSP	Integrated Logistics Support Plan
IMP	Interoperability Management Plan
IOC	Initial Operating Capability
IP	Imaging Processor
ISIS	Integrated Signals Intelligence System
ITT	Interrogation Translation Team
JCS	Joint Chiefs of Staff
JSIPS	Joint Service Imagery Processing System
JSP	Joint Service Program
JTC^3A	Joint Tactical C^3 Agency
LAAD	Low Altitude Area Defense
LAAM	Light Antiaircraft Missile Battalion
LCAC	Landing Craft Air Cushion
LCCF	Life Cycle Cost Forecast
LHD	Amphibious Assault Ship
MACCS	Marine Air Command and Control System
MAFATDS	Multi-service Advanced Field Artillery Tactical Data System
MAGIS	Marine Air-Ground Intelligence System
MAGTF	Marine Air Ground Task Force
MAP	Master Acquisition Plan
MATCALS	Marine Air Traffic Control and Landing System
MCASS	MTACCS Common Application Support Software
MCCDC	Marine Corps Combat Development Command
MCEB	Military Communications Electronics Board
MCICMP	Marine Corps Interoperability Configuration Management Plan
MIRC	MAGTF Interoperability Requirements Concept
MCO	Marine Corps Order
MCOTEA	Marine Corps Operational Test and Evaluation Activity
MCDEC	Marine Corps Development and Education Command
MCRDAC	Marine Corps Research, Development, and Acquisition Command
MCTSSA	Marine Corps Tactical Systems Support Activity
MEB	Marine Expeditionary Brigade
MEF	Marine Expeditionary Force
MEU	Marine Expeditionary Unit
MIFASS	Marine Integrated Fire and Air Support System
MILOGS	Marine Integrated Logistics System

MIPLOG	Marine Integrated Personnel and Logistics
MIPS	Marine Integrated Personnel System
MOE	Measure of Effectiveness
MOFE	Measure of Force Effectiveness
MOP	Measure of Performance
MTACCS	Marine Tactical Command and Control System
MTP	Manpower Training Plan
MTS	Marine Tactical System
NAVELEX	Naval Electronic Systems Command
NRAC	Naval Research Advisory Committee
NDI	Non-Developmental-Item
OMB	Office of Manpower and Budget
OSP	Other Service Program
OT	Operational Test
P^3I	Preplanned Product Improvement Plan
PDA	Principle Development Activity
PEO	Program Executive Officer
PLI	Position Location Information
PLRS	Position Location Reporting System
PM	Program Manager
PNL	Pacific Northwest Laboratories
POM	Program Objective Memorandum
RD&S	Research, Development, and Studies
RDT&E	Research, Development, Testing, and Evaluation
Ret	Retired
RGS	Remote Ground Sensor
ROC	Required Operational Capability
RPV	Remotely Piloted Vehicle
SAE	Service Acquisition Executive
SBB	Switched Backbone
SCR	Single Channel Radio
SDI	Strategic Defense Initiative
SEMP	Systems Engineering Master Plan
SINCGARS	Single Channel Ground and Air Radio System
SPAWAR	Space and Naval Warfare Systems Command
SRI	Surveillance, Reconnaissance, and Intelligence
TACC	Tactical Air Command Center
TADC	Tactical Air Direction Center

TADIL	Tactical Digital Information Link
TAO	Tactical Air Operations
TAOC	Tactical Air Operations Center
TAOM	Tactical Air Operations Module
TAR	Tactical Air Request
TCAC	Technical Control and Analysis Center
TCO	Tactical Combat Operations System
TERPES	Tactical Electronic Reconnaissance Processing and Evaluation System
TESE	Tactical Exercise and Simulation System
TIDP	Technical Interface Design Plan
TRSS	Tactical Remote Sensor System
TWAES	Tactical Warfare Analysis and Evaluation System
TWSEAS	Tactical Warfare Simulation, Evaluation, and Analysis System
UCPS	Unit Commander's Personnel System
ULCS	Unit Level Circuit Switch
ULMS	Unit Level Message Switch
ULTDS	Unit Level Tactical Data Switch
USA	United States Army
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy

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